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Guidance on Remedial Actions for Superfund Sites with PCB Contamination

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Abstract: The document describes the recommended approach for evaluating and remediating Superfund sites with PCB contamination. It provides starting point cleanup levels for various media that may become contaminated and identifies other considerations important to ensuring protection of human health and the environment that these cleanup levels may not address. The guidance also describes how to develop remedial alternatives for PCB contaminated materials that are consistent with Superfund program expectations and requirements. The guidance concludes with a discussion of considerations unique to PCBs that should be considered in the nine criteria evaluation and likely tradeoffs between options that are likely to occur.

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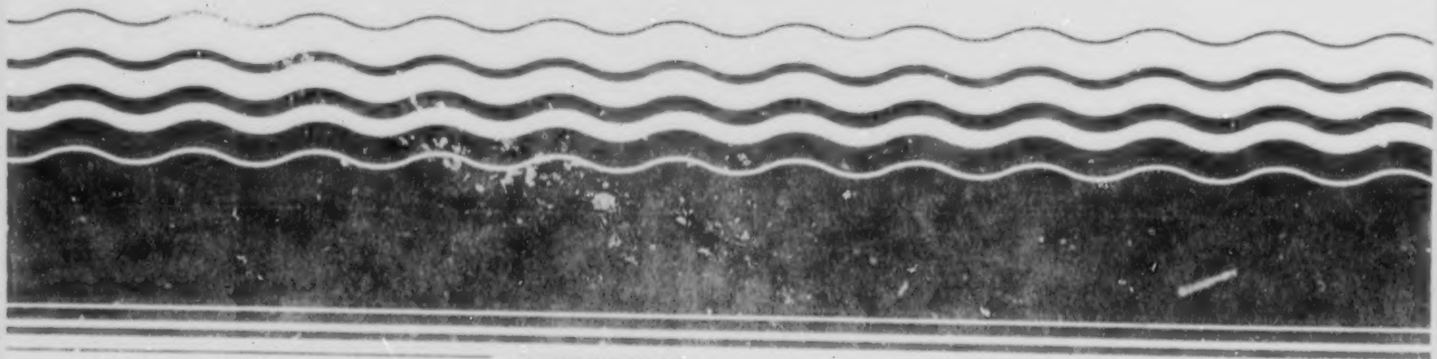

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GUIDANCE ON REMEDIAL ACTIONS FOR SUPERFUND SITES WITH PCB CONTAMINATION

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

NOTICE

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Executive Summary

This document describes the recommended approach for evaluating and remediating Superfund sites with PCB contamination. It should be used as a guide in the investigation and remedy selection process for PCB-contaminated Superfund sites. This guidance provides preliminary remediation goals for various media that may be contaminated and identifies other considerations important to ensuring protection of human health and the environment. In addition, potential applicable or relevant and appropriate requirements (ARARs) and "to-be-considered" criteria pertinent to Superfund sites with PCB contamination and their integration into the RI/FS and remedy selection process are summarized. This guidance also describes how to develop remedial alternatives for PCB contaminated materials that are consistent with Superfund program expectations and ARARs. The guidance concludes with a discussion of considerations unique to PCBs that should be considered in the nine criteria evaluation and tradeoffs between options that are likely to occur.

Actions taken at Superfund sites must meet the mandates of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as provided for in the National Contingency Plan (NCP). This requires that remedial actions protect human health and the environment, comply with or waive applicable or relevant and appropriate requirements, be cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, there is a preference for remedies that employ treatment that permanently and significantly reduces the mobility, toxicity, or volume of hazardous substances as a principal element. Although the basic Superfund approach to addressing PCB-contaminated sites is consistent with other laws and regulations, this consistency must be documented in the feasibility study and ROD to demonstrate that ARARs have been attained or waived. Primary Federal ARARs for PCBs derive from the Toxic Substances Control Act (TSCA) and the Resource Conservation and Recovery Act (RCRA).

To identify the areas for which a response action should be considered, starting point concentrations (preliminary cleanup goals) for each media are identified. These concentrations represent the level above which unrestricted exposure may result in risks exceeding protective levels. For soils, the preliminary remediation goals should generally be 1 ppm for sites in or expected to be in residential areas. Higher starting point values (10 to 25 ppm) are suggested for sites where non-residential land use is anticipated. Remediation goals for ground water that is potentially drinkable should be the proposed

MCL of .5 ppb. Cleanup levels associated with surface water should account for the potential use of the suface water as drinking water, impacts to aquatic life, and impacts through the food chain.

For contaminated material that is contained and managed in place over the long term, appropriate engineering and institutional controls should be used to ensure protection is maintained over time. An initial framework for determining appropriate long-term management measures is provided.

The Superfund program expectations should be considered in developing appropriate response options for the identified area over which some action must take place. In particular, the expectation that principal threats at the site should be treated, whenever practicable, and that consideration should be given to containment of low-threat material, forms the basis for assembling alternatives. Principal threats will generally include material contaminated at concentrations exceeding 100 ppm for sites in residential areas and concentrations exceeding 500 ppm for sites in industrial areas reflecting concentrations that are 1 to 2 orders of magnitude higher than the preliminary remediation goals. Where concentrations are below 100 ppm, treatment is less likely to be practicable unless the volume of contaminated material is relatively low.

The expectations support consideration of innovative treatment methods where they offer potential for comparable or superior treatment performance or implementability, fewer/lesser adverse impacts, or lower costs. This emphasizes the need to develop a range of treatment options. For PCBs, possible innovative technologies meeting these criteria include solvent extraction, potassium polyethylene glycol dechlorination (KPEG), biological treatment, and in-situ vitrification.

Protective, ARAR-compliant alternatives will be compared relative to the five balancing criteria: long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost. Primary tradeoffs are most likely to occur under the long-term effectiveness and permanence, implementability, and cost criteria.

Final decisions should document the PCB concentrations above which material will be excavated, treatment processes that will be used, action levels that define the area that will be contained, long-term management controls that will be implemented, treatment levels to which the selected remedy will reduce PCB concentrations prior to disposal, and the time frame for implementation.

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Chapter 1

Introduction

This document describes the recommended approach for evaluating and remediating Superfund sites with PCB contamination. It provides starting point cleanup levels for various media that may become contaminated and identifies other considerations important to ensuring protection of human health and the environment that these cleanup levels may not address. In addition, potential applicable or relevant and appropriate requirements (ARARs) and "to-be-considered" criteria pertinent to Superfund sites with PCB contamination and their integration into the RI/FS and remedy selection process are summarized.

The guidance also describes how to develop remedial alternatives for PCB contaminated materials that are consistent with Superfund program expectations and ARARs. The guidance concludes with a discussion of considerations unique to PCBs that should be considered in the nine criteria evaluation and likely tradeoffs between options that are likely to occur.

1.1 Purpose

This guidance document outlines the RI/FS and selection of remedy process as it specifically applies to the development, evaluation, and selection of remedial actions that address PCB contamination at Superfund sites. The principal objectives of this guidance are to:

- Present the statutory basis and analytical framework for formulating alternatives designed to address PCB contamination, explaining in particular the regulatory requirements and other criteria that can shape options for remediation;
- Describe key considerations for developing remediation goals for each contaminated media under various scenarios;
- Outline options for achieving the remediation goals and the associated ARARs;
- Summarize the key information that generally should be considered in the detailed analysis of alternatives;
- Discuss key tradeoffs likely to occur in the remedy selection process;
- Provide guidelines for documenting remedies for PCB sites in a Proposed Plan and Record of Decision.

Although technical aspects of the investigation, evaluation, and remediation are not discussed in detail, pertinent references and, in some cases, summary information, are provided.

This document is intended for use by EPA remedial project managers (RPMs), State and other Federal Agency site managers responsible for Superfund sites involving PCBs, contractors responsible for conducting the field work and alternatives evaluation at these sites, and others involved in the oversight or implementation of response actions at these sites.

Although each Superfund site may present a unique set of environmental conditions and potential human health problems, general guidelines can be established for sites involving PCBs as the predominant chemical. Utilizing these general principles, site managers can streamline the RI/FS and remedy selection process by conducting a more efficient and effective study. This can be accomplished by: 1) specifying ARARs and other factors that shape the primary options for remediating such sites, 2) identifying key information necessary to fully evaluate those options, and 3) focussing on the major tradeoffs likely to emerge in the comparative analysis upon which remedy selection is based. Consideration of the factors outlined in this document should lead to consistent alternatives development and evaluation at sites involving PCB contamination.

1.2 Background

Approximately 12 percent of the Superfund sites for which Records of Decision (RODs) have been signed (69 of 581 total RODs as of 9/89) address PCB contamination. Preliminary assessment/site inspection data from all sites on the National Priorities List indicates that approximately 17 percent of the sites for which RODs have not yet been signed also involve PCBs. The RI/FS/remedy selection process for PCB sites is complicated for a number of reasons. From a regulatory point of view, there is an unusually high number of potentially applicable or relevant and appropriate requirements (ARARs) and pertinent "to-be-considered" guidelines for actions involving PCB wastes. PCBs are difficult to address technically due to their persistence and high toxicity. Finally, a large number of process options are potentially effective for addressing PCBs and deserve consideration. The approach outlined in this document attempts to address all three aspects of PCB remediation.

1.3 Focus of This Document With Respect to the Remedial Process and Superfund Expectations

The Superfund remedial process begins with the identification of site problems during the preliminary assessment/site inspection, which is conducted before a site is listed on the National Priorities List. The process continues through site characterization, risk assessment, and treatability studies in the RI, the development, screening, and detailed analysis of remedial alternatives in the FS, and culminates in the selection, implementation, and operation of a remedial action. Figure 1-1 shows the steps comprising the Superfund RI/FS process. Arrows indicate key decisions specifically addressed in this document.

The various components of the remedial investigation are not specifically addressed in this document; however, initial reference material including tables outlining properties of PCBs, analytical methods available, and data collection needs/considerations for technologies used to address PCBs are provided. In addition, a general discussion of the assessment of PCB impact on ground water

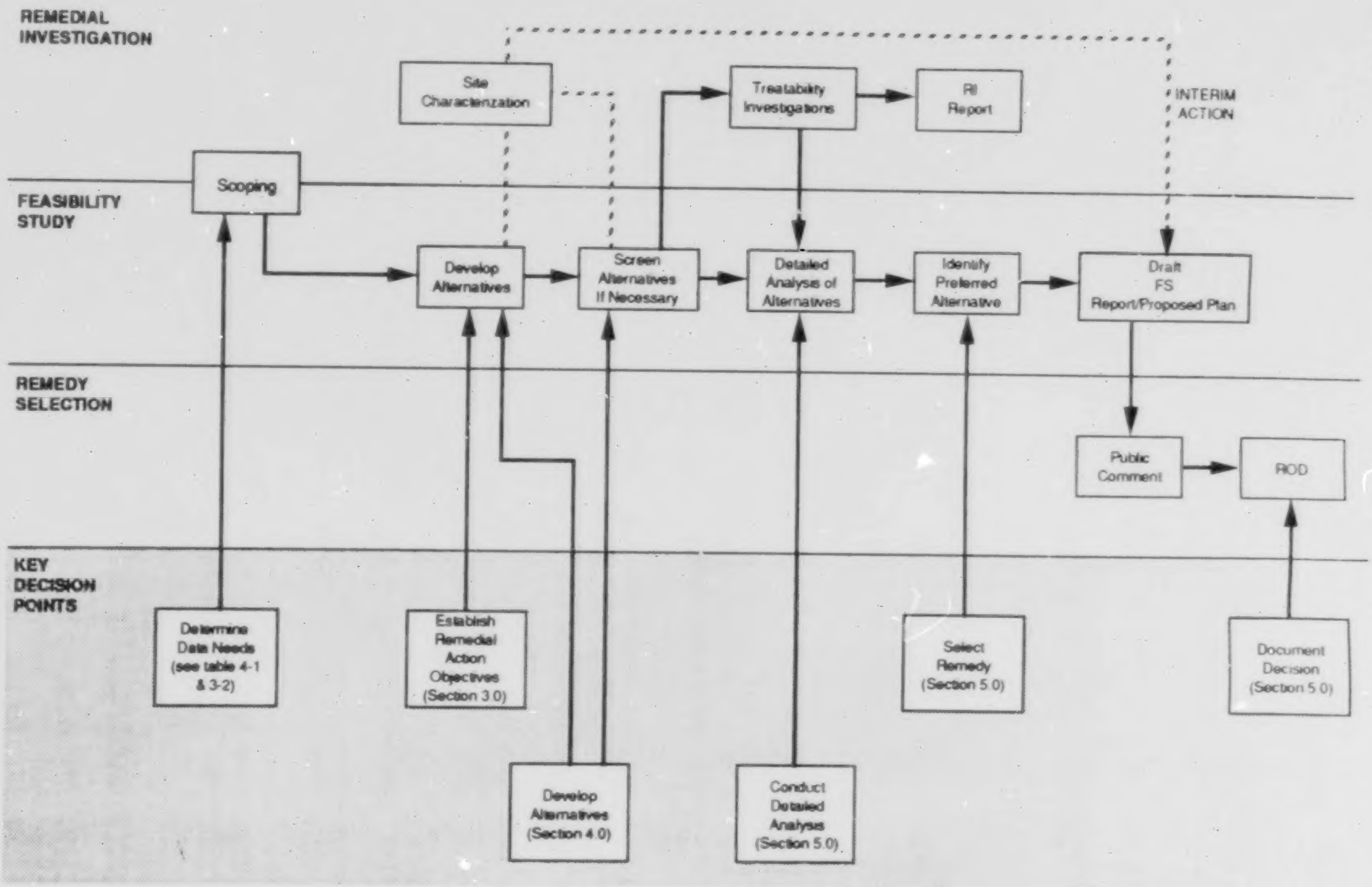
REMEDIAL INVESTIGATION
FEASIBILITY STUDY
REMEDY SELECTION
KEY DECISION POINTS
Site Characterization
Treatability Investigations
RI Report
INTERIM ACTION
Scoping
Develop Alternatives
Screen Alternatives If Necessary
Detailed Analysis of Alternatives
Identify Preferred Alternative
Draft FS Report/Proposed Plan
Public Comment
ROD
Determine Data Needs (see table 4-1 & 3-2)
Establish Remedial Action Objectives (Section 3.0)
Develop Alternatives (Section 4.0)
Conduct Detailed Analysis (Section 5.0)
Select Remedy (Section 5.0)
Document Decision (Section 5.0)

Figure 1-1 DECISION POINTS IN THE SUPERFUND PROCESS

and evironmental considerations which may be pertinent in the risk assessment is provided.

The focus of this guidance is primarily on the feasibility study: development and screening of alternatives, detailed analysis of alternatives, and the consequent selection of remedy. This process is designed to meet the overall Superfund goal to select remedial actions that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste. In addition to the overall goal, Superfund actions should consider the following program expectations:

- Treatment of principal threats wherever practicable,
- Containment of waste that poses a low long-term threat or where treatment is impracticable,
- Institutional controls to mitigate short-term impacts or supplement engineering controls,
- Remedies that combine treatment of principal threats with containment and institutional controls for treatment residuals and untreated waste,
- Consideration of innovative technologies,
- Returning contaminated ground water to its beneficial uses within a time frame that is reasonable, where practicable.

The implications of these expectations for PCB contaminated sites is described in appropriate sections of this document.

The development of alternatives involves completing the following steps, considering the program expectations described above:

1. Identify remedial action response objectives including the preliminary remediation goals that define the appropriate concentration of PCBs that could remain at the site without management controls.

2. Identify general response actions such as excavation and treatment, containment, or in-situ treatment. Identify target areas for treatment and containment consistent with Superfund program expectations and consistent with ARARs and TBCs specific to PCB contamination.

3. Identify process options for various response actions. Treatment options for PCBs include incineration,

solvent extraction, KPEG, or other removal/destruction methods. Immobilization techniques may also be considered. Long-term management controls appropriate for the material remaining on site should be noted.

4. Evaluate/screen process options to determine which are technically feasible for the site.

5. Combine feasible process options to formulate alternative remedial actions for detailed analysis.

This document provides general guidance on two primary aspects of the development of alternatives process that are considered and revised throughout the completion of the steps listed above:

- Determination of the appropriate concentration of PCBs that can remain at a site (remediation goal) under various site use assumptions. This is based on standard exposure and fate assumptions for direct contact. A qualitative consideration of potential migration to ground water and environmental impacts is included for site-specific assessment.

  This concentration will reflect the level that will achieve the program goal of protection and will be achieved through removal and treatment to this level or by restricting exposure to contamination remaining above this level.

- Identification of options for addressing contaminated material and the implications, in terms of long-term management controls, associated with these options. Remedial actions will fall into three general categories: overall reduction of PCB concentrations at the site through removal or treatment) such that the site can be used without restrictions, complete containment of the PCBs present at the site with appropriate long-term management controls and access restrictions, and a combination of these options in which high concentrations are reduced through removal or treatment but the levels remaining still warrant some management controls.

The determination of what combination of treatment and containment is appropriate will be guided by the program expectations to treat the principal threats and contain and manage low-threat material. The determination of what constitutes a principal threat will be site-specific but will generally include material contaminated at concentrations of PCBs that exceed 100 ppm (residential areas) or 500 ppm (industrial areas).

> The type of treatment selected will take into account the program expectation to consider innovative treatment. Treatment that is often comparable in performance to but less costly than incineration may be attained using solvent extraction or KPEG. In addition, the potential for adverse affects from incineration can be removed through use of one of these technologies, in-situ vitrification, and in some cases, solidification.

For both evaluations, pertinent ARARs and TBCs are identified.

Finally, this document will: 1) discuss some of the unique factors associated with response actions at PCB-contaminated sites that might be considered under the detailed analysis of alternatives using the evaluation criteria outlined in the proposed NCP, 2) indicate how these factors might be evaluated in selecting the site remedy, and 3) outline the findings that should be documented for the selected remedy.

1.4 Organization of Document

The remainder of this document is divided into four chapters and six appendices, summarized below. At the beginning of each chapter a brief summary highlighting the main points of the section is provided.

Chapter 2 describes the potential ARARs and TBCs most commonly identified for sites involving PCB contamination. This discussion has been separated from the background section because of the complexity of the regulatory framework.

Chapter 3 provides general guidelines for determining PCB concentrations appropriate to leave on site under various scenarios. The primary factors affecting this determination are the medium that is contaminated, the exposure assumptions for the site, and the extent and level of contamination that is to be addressed.

Chapter 4 outlines the remediation options for material which warrants active response. Options include treatment that destroys the PCBs and long-term management controls that prevent exposure to PCBs. The regulatory implications of each option are discussed.

Chapter 5 summarizes the primary considerations associated with determining the appropriate response action for a PCB contaminated Superfund site in terms of the nine evaluation criteria used in the detailed analysis. Key tradeoffs likey to occur among alternatives are noted.

Finally, the findings specific to actions addressing PCBs that should be documented in the Record of Decision are presented.

Appendix A provides a summary of the Superfund sites involving PCBs for which RODs have been signed, including type of response action chosen and clean-up levels specified.

Appendix B provides the detailed calculations supporting the direct contact risk evaluation presented in Chapter 3.

Appendix C provides the backup calculations and methodology for the example evaluation of long term management controls presented in Chapter 4.

Appendix D includes two case studies of Superfund site actions involving PCB contamination: Peppers Steel, FL where the remedy involved solidification and Wide Beach, NY where treatment using the KPEG process was selected.

Appendix E provides a list of the currently permitted PCB disposal companies and their addresses and phone numbers. It also includes a list of EPA's Regional PCB disposal contacts in the TSCA program and their phone numbers.

Appendix F provides examples of long-term management controls implemented at several PCB Superfund sites where varying concentrations of PCBs were left on site.

Chapter 2

Potential ARARs and "To-Be-Considered" Guidelines Pertinent to PCB Contamination Sites

Actions taken at Superfund sites must meet the mandates of CERCLA as provided for in the NCP. This requires that remedial actions protect human health and the environment, comply with or waive applicable or relevant and appropriate requirements, be cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, there is a preference for remedies that employ treatment that permanently and significantly reduces the mobility, toxicity, or volume of hazardous substances as a principal element. Although the basic Superfund approach to addressing PCB-contaminated sites is consistent with other laws and regulations, this consistency must be documented in the feasability study and ROD to demonstrate that ARARs have been attained or waived. Primary Federal ARARs for PCBs derive from the Toxic Substances Control Act (TSCA) and the Resource Conservation and Recovery Act (RCRA).

TSCA requires that material contaminated with PCBs at concentrations of 50 ppm or greater be disposed of in an incinerator or by an alternate method that achieves a level of performance equivalent to incineration. Liquids at concentrations above 50 ppm but less than 500 ppm and soils contaminated above 50 ppm may also be disposed of in a chemical waste landfill.

RCRA requirements apply to PCBs when liquid waste that is hazardous under RCRA contains PCBs at concentrations greater than 50 ppm or non-liquid hazardous waste contains total HOCs at concentrations greater than 1000 ppm. The land disposal restrictions require that prior to placing this material on the land, it must be incinerated unless a treatability variance is obtained.

Other requirements that derive from the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) and their implementing regulations may apply or be relevant and appropriate when the site involves surface or ground water contamination.

2.1 National Contingency Plan (NCP) (U.S. EPA, 1990a)

The primary regulation that governs actions at PCB-contaminated Superfund sites is, of course, the National Contingency Plan (NCP), which defines the framework for addressing the requirements of CERCLA. The provisions of the NCP form the basis for the guidance provided in this document and will not be discussed in detail here but will be discussed in each section as they form the basic structure for the approach. The NCP implements the following CERCLA requirements:

- o Protect human health and the environment (CERCLA Section 121(b))
- o Comply with the applicable or relevant and appropriate requirements (ARARs) of Federal and State laws (CERCLA Section 121 (d)(2)(A)) or justify a waiver (CERCLA Section 121 (d)(4))
- o Be cost-effective, taking into consideration short- and long-term costs (CERCLA Section 121(a))
- o Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable (CERCLA Section 121(b))
- o Satisfy the preference for remedies that employ treatment that permanently and significantly reduces the mobility, toxicity, or volume of hazardous substances as a principal element or provide in the ROD an explanation of why treatment was not chosen. (CERCLA Section 121(b))

The nine evaluation criteria discussed in Section 5 are designed to elicit the appropriate information that will form the basis for demonstrating that these requirements have been satisfied. Because remedies must attain the ARARs of other Federal and State laws, some background and summary material on the ARARs that address PCB contamination is presented in this section.

ARARs for treating or managing PCB-contaminated material derive primarily from two sets of regulations: the Toxic Substances Control Act (TSCA) PCB regulations and the Resource Conservation and Recovery Act (RCRA) land disposal restrictions (LDRs). Where PCBs affect ground or surface water, the Safe Drinking Water Act (SDWA) and Clean Water Act (CWA) may provide potential ARARs for establishing remediation goals; i.e., Maximum Contaminant Levels (MCLs), Maximum Contaminant Level Goals (MCLGs), and Water Quality Criteria (WQC). In addition, the PCB Spill Policy, which is not an ARAR although it is published in the Code of Federal Regulations, should be considered when determining cleanup levels at a site. Other "to-be-considered" (TBC) information is provided by guidances developed by the Office of Toxic Substances to assist in implementing the PCB regulations of TSCA.

2.2 TSCA PCB Regulations

The TSCA PCB regulations of importance to Superfund actions are found in 40 CFR Section 761.60 - 761.79, Subpart D: Storage and Disposal. They specify treatment, storage, and disposal requirements for PCBs based on their form and concentration. The disposal options for PCB-contaminated material are summarized in Table 2-1 and discussed in the following sections. A final section describes the storage requirements.

TSCA requirements do not apply to PCBs at concentrations less than 50 ppm; however, PCBs cannot be diluted to escape TSCA requirements. Consequently, under TSCA PCBs that have been deposited in the environment after the effective date of the regulation, February 17, 1978, are treated, for the purposes of determining disposal requirements, as if they were at the concentration of the original material. For example, if PCB transformers leaked oil containing PCBs at greater than 500 ppm, the soil contaminated by the oil would have to excavated and disposed of as if all of the PCB-contaminated soil contained PCBs at greater than 500 ppm. This reflects an interpretation of the anti-dilution provisions in TSCA (40 CFR 761.1(b)) and was developed with the intent of eliminating the incentive responsible parties might have to dilute wastes in order to avoid regulation.

EPA has clarified that the TSCA anti-dilution provisions are only applicable to CERCLA response actions that occur once a remedial action is initiated (U.S. EPA, 1990a). In selecting response action strategies and cleanup levels under CERCLA, EPA should evaluate the form and concentration of the PCB contamination "as found" at the site, and dispose of it in accordance with the requirements of 40 CFR 761.60(a)(2) - (5). Cleanup levels and technologies should not be selected based on the form and concentration of the original PCB material spilled or disposed of at the site prior to EPA's involvement (i.e., the anti-dilution provision of the PCB rules should not be applied). Because EPA comes to a site under the CERCLA after the pollution has already occurred, and is acting under statutory mandate to select a proper cleanup level, EPA is not subject to the anti-dilution provision at CERCLA sites when it selects a remedy. However, the Agency may not further dilute the PCB

Table 2-1
REMEDIATION OPTIONS FOR PCB WASTE UNDER TSCA

PCB waste category	40 CFR Section	PCB concentration (ppm)	Incinerator (§761.70)	Chemical waste landfill (§761.75)	High efficiency boiler (§761.60)	Alternative method (§761.60(e))	Method approved by region	Drain, dispose as solid waste	Decontamination
Liquid PCB	761.60	≥500	X			X			
Liquids with flash point > 60° C	761.75	50-500	X	X	X	X			
Liquids with flash point < 60° C	761.75	50-500	X		X	X			
Other liquids that are also hazardous wastes	268.42[a][1]	50-500	X		X	X			
Other liquids that are also hazardous wastes	268.42[a][1]	≥500	X			X			
Nonliquids (soil, rags, debris)	761.60[a][4]	≥50	X	X		X			
Dredged materials and minicipal sewage sludge	761.60[a][5]	≥50	X	X		X	X		
PCB transformers (drained and flushed)	761.60[b][1]	NS[a]	X	X					
PCB capacitors[b]	761.60[b][2]	≥500	X						
PCB capacitors	761.60[b][4]	50-500	X	X					
PCB hydraulic machines	761.60[b][3]	≥50						X[c,d]	
PCB contaminated electrical equipment (except capacitors)	761.60[b][4]							X[e]	
Other PCB articles	761.60[b][5]	≥500[f]	X	X[g]					
Other PCB articles	761.60[b][5]	50-500						X[e]	
PCB containers	761.60[c]	≥500[f]	X	X[d]					X[h]
PCB containers	761.60[c]	<500						X[d]	X[h]
All other PCBs	761.60[a]	≥50	X			X			

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[a] Not specified.

[b] Exemptions for some small capacitors.

[c] Must also be flushed if hydraulic fluid contains >1,000 ppm PCBs and flushing solvent disposed of in accordance with §761.60(a).

[d] Drained liquid must be disposed of in accordance with §761.60(a).

[e] Must be drained of all free-flowing liquid. The disposal of the drained electrical equipment and other PCB articles is not regulated by 40 CFR 761. All liquids must be disposed of in accordance with paragraph (a)(2) or (3) of §761.60 [in an incinerator (§761.70), chemical waste landfill (761.75), high efficiency boiler, or by an alternative method (§761.60(e))].

[f] Due to a typographical error, 40 CFR 761 (July 2, 1985, p. 163) erroneously states this value as 50 ppm; refer to Federal Register, 44, 31514-31568 (May 3,1979) (USEPA).

[g] Drained of any free-flowing liquid and liquid incinerated in a §761.70 incinerator.

[h] Decontaminated in compliance with §761.79.

waste in order to avoid the TSCA PCB disposal requirements as part of a CERLCA cleanup.

2.2.1 Liquid PCBs at Concentrations Greater Than 500 ppm

Remediation Options for PCB Waste Under TSCA/RCRA

Waste Cat.	40CFR Sec.	Incin. 761.70	High Eff. Boiler 761.60	Alt. Method 761.60(e)
Liquid PCB	761.60	X		X
Other Liq. also Haz.	268.42(a)(1)	X		X

Liquid PCBs at concentrations greater than 500 ppm must be disposed of in an incinerator which complies with 40 CFR 761.70 or by an alternative disposal method that achieves a level of performance equivalent to incineration as provided under 761.60(e). This has been interpreted to imply that treatment residuals must contain less than 2 ppm PCBs.

2.2.2 Liquid PCBs at Concentrations Between 50 ppm and 500 ppm

Remediation Options for PCB Waste Under TSCA/RCRA

Waste Cat.	40CFR Sec.	Incin. 761.70	High Eff. Boiler 761.60	Alt. Method 761.60(e)	Chem. Waste Landfl. 761.75
Liq. w/ flash pt > 60C	761.75	X	X	X	X
Liq. w/ flash pt < 60C	761.75	X	X	X	
Other liq. also haz.	268.42(a)(a)	X	X	X	

Liquid PCBs at concentrations between 50 ppm and 500 ppm, can be disposed of in an incinerator or high efficiency boiler as described above, or in a facility that provides an alternative method of destroying PCBs that achieves a level of performance equivalent to incineration (equivalent method) approved under 40 CFR 761.60(e) (i.e., demonstrate achievement of less than 2 ppm PCBs in the treatment residual).

Liquids at these concentrations with a flash point greater than 60 degrees Centigrade (not considered ignitable as defined in 761.75(b)(8)(iii)) other than mineral oil dielectric fluid, can also be disposed of in a chemical waste landfill which complies with 40 CFR 761.75. However, the following actions must be taken:

- o Bulk liquids must be pretreated and/or stabilized (e.g., chemically fixed, evaporated, mixed with dry inert absorbant) to reduce its liquid content or increase its solid content so that a non-flowing consistency is achieved;
- o Containers of liquid PCBs must be surrounded by an amount of inert sorbant material capable of absorbing all of the liquid contents of the container.

2.2.3 Non-Liquid PCBs at Concentrations Greater Than or Equal to 50 ppm

Remediation Options for PCB Waste Under TSCA/RCRA

Waste Cat.	40CFR Sec.	Incin. 761.70	Alt. Treatmt. 761.60(e)	Chem. Waste Landfl. 761.75	Method Apprvd. by RA 761.60(a)(5)
Non-liq. soil, rags, debris	761.60(a)(4)	X	X	X	
Dredged material, munic. sewage sludge	761.60(a)(5)	X	X	X	X

Soils and municipal sludges contaminated with PCBs at concentrations greater than or equal to 50 ppm can be disposed of in an incinerator, treated by an equivalent method, or disposed of in a chemical waste landfill. Industrial sludges with PCB concentrations greater than 500 ppm may not be landfilled. The determination of whether contaminated material should be considered a soil or an industrial sludge should be made site specifically consistent with the current process for classifying material subject to the land disposal restrictions as either a pure waste or a soil and debris contaminated with a waste.

Dredged materials and municipal sewage treatment sludges that contain PCBs at concentrations greater than or equal to 50 ppm can also be disposed of by methods other than those noted above that are approved by the Regional Administrator. It must be demonstrated that disposal in an incinerator or chemical waste landfill is not reasonable and appropriate, and that the alternate disposal method will provide adequate protection to health and the environment.

2.2.4 PCB Articles, Containers, Electrical Equipment

Remediation Options for PCB Waste Under TSCA/RCRA

Waste Cat.	40CFR Sec.	Incin. 761.70	Alt. Treatmt. 761.60(e)	Chem. Waste Landfl. 761.75	Drain Dispose as sol. waste	Decon.
PCB transformers	761.60(b)(1)	X	X	X		
PCB capacitors (>= 500 ppm)	761.60(b)(2)	X	X			
PCB capacitors (50 - 500 ppm)	761.60(b)(4)	X	X	X		
PCB hyd. machines	761.60(b)(3)				X	
PCB elec. equip.	761.60(b)(4)				X	
PCB articles (>=500 ppm)	761.60(b)(5)	X	X	X		
PCB articles (50 - 500 ppm)	761.60(b)(5)				X	
PCB containers (>=500 ppm)	761.60(c)	X	X	X		X
PCB containers (<500 ppm)	761.60(c)				X	X

PCB transformers and capacitors (by definition (40CFR 761.60) these contain 500 ppm PCB or greater as opposed to

PCB-contaminated electrical equipment which contains less than 500 ppm) must be disposed of in an incinerator, by an alternate method which can achieve a level of performance equal to incineration, or in a chemical waste landfill. However, special procedures must be followed for disposing of transformers in chemical waste landfills and a special showing indicating that incineration capacity does not exist, that incineration of the capacitors will interfere with the incineration of liquid PCBs, or other good cause, must be made for disposing capacitors in landfills. These are described in 40 CFR 761.60(b).

PCB-contaminated electrical equipment (this includes transformers and other equipment other than capacitors which contain PCBs between 50 ppm and 500 ppm) must be drained of all free flowing liquid. The liquid must be disposed of in an incinerator, by an equivalent method, or in a chemical waste landfill. The drained equipment is not covered under TSCA regulations. PCB-contaminated capacitors must be disposed of in an incinerator or a chemical waste landfill.

PCB articles and containers with PCB concentrations greater than 500 ppm must be incinerated or disposed of in a chemical waste landfill provided all free flowing liquid is drained and incinerated. PCB articles and containers with PCB concentrations between 50 ppm and 500 ppm must be disposed of by draining all free flowing liquid and appropriately disposing of the liquid. The drained articles and containers can be disposed of as municipal solid waste.

2.2.5 TSCA Chemical Waste Landfill Requirements

The requirements for chemical waste landfills are described in 40 CFR Section 761.75 and outlined in Table 2-2. As indicated, the regulations do not require caps because the regulations were designed for operating landfills. Where Superfund remedial actions will leave PCBs in place or where PCB-contaminated material is excavated, treated, and re-disposed at concentrations that still pose a threat, capping consistent with chemical waste landfill requirements is generally appropriate. (Long-term management controls for PCB-contaminated material generally will also parallel RCRA closures.) However, some of the requirements specified under TSCA may not always be appropriate for existing waste disposal sites like those addressed by Superfund. When this is the case, it may be appropriate to waive certain requirements, such as liners, under the TSCA waiver provisions, 761.75(c)(4). Requirements may be waived when it can be demonstrated that operation of the landfill will not present an unreasonable risk of injury to health or the environment. This

Table 2-2
TSCA CHEMICAL WASTE LANDFILL REQUIREMENTS
(40 CFR SECTION 761.75)

1. Located in thick, relatively impermeable formation such as large area clay pans, or:

   - On soil with high clay and silt content with the following parameters:
     - in-place soil thickness of four feet or compacted soil liner thickness of three feet
     - permeability equal to or less than 1×10^{-7}
     - percent soil passing No. 200 Sieve, greater than 30
     - liquid limit greater than 30
     - plasticity index greater than 15.

   - On a synthetic membrane liner (minimum thickness of 30 mils.) providing permeability equivalent to the soil described above including adequate soil underlining and soil cover to prevent excessive stress on or rupture of the liner.

2. A. Bottom of the landfill liner system or natural in-place soil barrier at least 50 feet from the historical high ground water table. Floodplains, shorelands, and ground water recharge areas shall be avoided and there shall be no hydraulic connection between the site and standing or flowing surface water.

   B. If the landfill is below the 100-year floodwater elevation, surface water diversion dikes should be constructed around the perimeter with a minimum height equal to two feet above the 100-year floodwater elevation.

   If the landfill is above the 100-year floodwater elevation, diversion structures capable of diverting all of the surface water runoff from 24-hour, 25-year storm.

3. Located in an area of low to moderate relief to minimize erosion and to help prevent landslides or slumping.

4. Sampling of designated surface watercourses monthly during disposal activities and once every six months after disposal is completed.

5. Ground water monitoring at a minimum of three points (equally spaced on a line through the center of the landfill), sampling frequency determined on a site specific basis (not specified in regulation) samples analyzed for PCBs, pH, specific conductance, and chlorinated organics.

6. Leachate Collection System:

   A. Gravity flow drainfield installed above the liner (recommended for use when semi-solid or leachable solid wastes are placed in a lined pit excavated into a relatively unsaturated homogeneous layer of low permeable soil) or

   B. Gravity flow drainfield installed above the liner and above a secondary liner (recommended for use when semi-liquid or leachable solid wastes are placed in a lined pit excavated into relatively permeable soil) or

   C. Network of porous ceramic cups connected by hoses/tubing to a vacuum pump installed along the sides and under the bottom of the waste disposal facility liner (recommended for relatively permeable unsaturated soil immediately adjacent to the bottom and/or sides of the disposal facility).

7. Installation of a six foot woven mesh fence, wall, or similar device to prevent unauthorized persons and animals.

Note: Waiver Provision (761.75 (c)(4))- One or more of the above requirements may be waived as long as operation of the landfill will not present an unreasonable risk of injury to health or the environment.

demonstration may require column studies verifying that PCB movement through the soil will not adversely affect ground water. These waivers are distinct from the six waivers from ARARs provided under CERCLA Section 121(d)(2), which may also be invoked under appropriate circumstances.

2.2.6 Storage Requirements

The requirements for storage of PCBs are described in 40 CFR Section 761.65. The regulations specify that PCBs at concentrations of 50 ppm or greater must be disposed of within one year after being placed in storage. The regulations also include structural requirements for facilities used for the storage of PCBs and requirements for containers used to store PCBs.

PCBs stored as part of a Superfund action should be placed in facilities that meet the following specifications:

- o Provide an adequate roof and walls to prevent rain water from reaching the stored PCBs,
- o Provide an adequate floor which has continuous curbing with a minimum six inch high curb,
- o Contain no drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area,
- o Floors and curbing constructed of continuous smooth and impervious materials, to minimize penetration of PCBs; and
- o Not located at a site that is below the 100-year flood water elevation.

PCBs subject to TSCA should not be stored longer than one year. In some cases, PCB-contaminated material may be generated during the RI/FS that will require storage that may exceed the one-year limitation under TSCA. Where the final disposition of the waste will be specified in the ROD, the exceedence of the TSCA storage limitation may be justified using a CERCLA waiver. An interim remedy waiver under CERCLA could be invoked. Since the removal action is interim in nature and the remedy determined in the ROD will comply with ARARs for final disposition of the waste, a waiver of the ARAR is justified. A memorandum supporting the action should be prepared and placed in the administrative record to document the finding.

2.3 RCRA Regulations Addressing PCBs

Closure requirements described under RCRA are considered potentially applicable or relevant and appropriate at Superfund sites. A detailed discussion of these requirements is not presented in this document since they are not specific to PCBs. Instead, guidelines for long term management controls consistent with RCRA closure requirements that are warranted under various closure scenarios are provided in section 4.3. (Further discussion of the closure requirements under RCRA and their use at Superfund sites can be found in the CERCLA Compliance With Other Laws Manual (U.S. EPA, 1989b).)

PCBs are specifically addressed under RCRA in 40 CFR 268 which describes the prohibitions on land disposal of various hazardous wastes. Note that RCRA regulations only apply to waste that is considered hazardous under RCRA; i.e., listed in 40 CFR 261.3 or characteristic as described in 40 CFR 261.2. PCBs alone are not a RCRA hazardous waste; however, if the PCBs are mixed with a RCRA hazardous waste they may be subject to land disposal restrictions as summarized below.

PCBs are one of the constituents addressed by the land disposal restrictions under the California List Wastes. This subsection of wastes covers liquid hazardous wastes containing PCBs at concentrations greater than or equal to 50 ppm and non-liquid hazardous wastes containing total concentrations of Halogenated Organic Compounds (HOCs) at concentrations greater than 1000 ppm. PCBs are included in the list of HOCs provided in the regulation (Appendix III part 268).

2.3.1 Liquid Hazardous Waste With PCBs at 50 ppm or Greater

As described in 40 CFR 268.42(a)(1), liquid hazardous (RCRA listed or characteristic) wastes containing PCBs at concentrations greater than or equal to 500 ppm must be incinerated in a facility meeting the requirements of 40 CFR 761.70. Liquid hazardous wastes containing PCBs at concentrations greater than or equal to 50 ppm but less than 500 ppm must be incinerated or burned in a high efficiency boiler meeting the requirements of 40 CFR 761.60.

A method of treatment equivalent to the required treatment may also be used under a treatability variance procedure if the alternate treatment can achieve a level of performance equivalent to that achieved by the specified method as described in 40 CFR 268.42(b).

2.3.2 Hazardous Waste With HOCs at 1000 ppm or Greater

Liquid and non-liquid hazardous wastes containing HOCs in total concentration greater than or equal to 1000 ppm must be incinerated in accordance with the requirement of 40 CFR 264 Subpart O.

Again, a method of treatment equivalent to the required treatment, under a treatability variance, may also be used.

Special considerations are pertinent for waste that falls into the category of soil and debris from a CERCLA remedial action or RCRA Corrective Action. The land disposal restrictions for CERCLA soil and debris went into effect November 8, 1988; however, no standards for disposal were published at that time. Consequently soil and debris contaminated with hazardous waste is banned from land disposal unless it meets existing standards for the pure waste or qualifies for a treatability variance. The preamble to the NCP, established a general presumption that a treatability variance is warranted for CERCLA soil and debris. Alternate treatment levels should be justified based on the treatability variance guidance levels (U.S. EPA, 1989h). For PCBs, residuals after treatment should contain .1 to 10 ppm PCBs for initial concentrations up to 100 ppm and above 100 ppm, treatment should achieve 90 to 99% reduction in concentration to qualify for a treatability variance.

Finally, hazardous wastes for which the treatment method is incineration or the treatment standard was based on incineration are subject to a 2-year capacity extension from the time that the standard went into place. Wastes that qualify for a capacity extension can be disposed without meeting the treatment requirements; however, they must be disposed of in a facility that is in compliance with the minimum technology requirements established for landfills in section 3004(o) of RCRA. The capacity extension for California List wastes when they are present in CERCLA soil and debris extends until November 8, 1990.

2.4 Clean Water Act

The Clean Water Act establishes requirements and discharge limits for actions that affect surface water. Water Quality Criteria (WQC) indicating concentrations of concern for surface water based on human exposure through drinking the water and ingesting fish as well as concentrations of concern to aquatic life have been developed for many compounds. For PCBs, the WQC for chronic exposure through drinking water and fish ingestion is .000079 ppb based on an excess cancer risk of 10^{-6}. This assumes consumption of 6.5 grams of estuarine fish and shellfish products and 2 liters of water per day over a 70 year lifetime. The level is the same if consumption of water is excluded indicating a relative negligible impact due to this source.

Acute toxicity to freshwater aquatic life is estimated to occur only at concentrations above 2 ppb. Acute toxicity to saltwater aquatic life is estimated to occur only at concentrations above 10 ppb. The water quality criteria for chronic effects are .014 ppb and .03 ppb for fresh and saltwater aquatic life, respectively.

These values are used as guides in the development of water quality standards for surface water that are enforced at the State level. States may account for other factors in establishing these standards including physical, chemical, biological, and economic factors. State standards and/or WQC are ARAR for surface water discharges. More detailed discussion of the CWA ARARs can be found in the CERCLA Compliance Manual (U.S. EPA, 1989b).

2.5 Safe Drinking Water Act

Under the Safe Drinking Water Act (SDWA), Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) are established. MCLs for carcinogens are generally set at levels that reflect an excess cancer risk due to drinking 2 liters of water per day over a 70 year life of between 10^{-4} and 10^{-6}. They are set as close as practicable to the MCLG (which for carcinogens is zero) accounting for the use of the best available technology, cost, and analytical capabilities. MCLs must be attained by public water supplies. MCLGs are goals set at levels that would result in no known or anticipated adverse effects to human health over a lifetime. At Superfund sites, MCLs and non-zero MCLGs may be relevant and appropriate to contaminated ground water that is or could be used as drinking water.

An MCL of .5 ppb was proposed for PCBs in May 1989 (U.S. EPA, 1989d). The MCLG is zero because PCBs are possible carcinogens. As a proposed MCL, the .5 ppb level is a TBC that EPA recommends be considered in determining the appropriate cleanup level for potentially drinkable ground water. (The MCL for PCBs is expected to be finalized by September 1990.) More detailed discussion of the SDWA ARARs can be found in the CERCLA Compliance Manual (U.S. EPA, 1989b).

2.6 PCB Spill Cleanup Policy Under TSCA

The PCB Spill Cleanup Policy was published in 40 CFR 761.120 - 761.139 on April 2, 1987 and describes the level of cleanup required for PCB spills occurring after May 4, 1987 (the effective date). Because it is not a regulation and only applies to recent spills (reported within 24 hours of occurrence), the Spill Policy is not ARAR for Superfund response actions; however, as a codified policy representing substantial scientific and technical evaluation it has been considered in developing the guidance cleanup levels discussed in section 3. A summary of the policy follows.

2.6.1 Low Concentration, Low Volume Spills All Areas

For spills of low concentration PCBs (50 ppm to 500 ppm) involving less than one pound of PCBs, cleanup in accordance with procedural performance requirements is required. The requirements consist of double wash rinse and cleanup of indoor residential surfaces to 10 micrograms (ug) per 100 square centimeters (cm2) analyzed by a wipe test, and excavation of all soils within the spill area plus a 1-foot lateral boundary of soil and other ground media and backfilling with clean (less than 1 ppm PCB) soil. No confirmation sampling is required.

2.6.2 Non-Restricted Access Areas

For spills of 500 ppm or greater PCBs and spills of low-concentration PCBs of more than one pound PCBs by weight in non-restricted access areas, materials such as household furnishings and toys must be disposed of and soil and other similar materials must be cleaned up to 10 ppm PCBs, provided that the minimum depth of excavation is 10 inches. In addition, a cap of at least 10 inches of clean materials must be placed on top of the excavated area. Indoor and outdoor surfaces must be cleaned to 10 ug/100 cm^2, but low contact outdoor surfaces may be cleaned to 100 ug/100 cm^2 and encapsulated. Post clean-up sampling is required.

2.6.3 Industrial Areas

For spills of 500 ppm or greater PCBs and spills of low-concentration PCBs of more than one pound in industrial and other restricted access areas, cleanup of soil, sand, and gravel to 25 ppm PCBs is required. Indoor high contact and outdoor high contact surfaces must be cleaned to 10 ug/100

cm^2. Indoor low contact surfaces may be cleaned to 10 ug/100 cm^2 or to 100 ug/100 cm^2 and encapsulated. Outdoor low contact surfaces may be cleaned to 100 ug/100 cm^2. Post cleanup sampling is required.

2.6.4 Outdoor Electrical Substations

For spills of 500 ppm or greater PCBs and spills of low-concentration PCBs of more than one pound at an outdoor electrical substation, cleanup of solid materials such as soils to 25 ppm or to 50 ppm (with a sign posted) is required. All surfaces must be cleaned to 100 ug/100 cm^2. Post cleanup sampling is required.

2.6.5 Special Situations

For particular situations, decontamination to site-specific requirements established by EPA Regional Offices is required. These situations are:

1. Spills that result in direct contamination of surface waters;
2. Spills that result in direct contamination of sewers or sewage treatment systems;
3. Spills that result in direct contamination of any private or public drinking water sources;
4. Spills which migrate to and contaminate surface waters, sewers, or drinking water supplies;
5. Spills that contaminate animal grazing land; and
6. Spills that contaminate vegetable gardens.

2.7 Guidances

Several documents have been produced that provide background information and guidance on complying with the regulations and policy described above. Pertinent information provided by some of the more important documents are described in this section. This material is "to-be-considered" in developing remedies at Superfund sites.

2.7.1 Draft Guidelines for Permit Applications and Demonstrations -- Test Plans for PCB Disposal by Non-Thermal Alternate Methods (U.S. EPA, 1986c)

The most significant information in this document affecting actions taking place at Superfund sites is the discussion provided on evaluating the "equivalency" of technologies to incineration. As described in section 2.2, most PCB-contaminated material can be treated by an alternate method provided that it can achieve a level of performance equivalent to an incinerator or a high efficiency boiler. The guidance manual indicates that an equivalent level of performance for an alternate method of treatment of PCB-contaminated material is demonstrated if it reduces the level of PCBs to less than 2 ppm measured in the treated residual. The residual can then be disposed of on-site without further regulation. Otherwise, the material must be treated as if it were contaminated at the original level (i.e., disposed of in a chemical waste landfill or incinerated).

This level was based on the practical limit of quantification for PCBs in an organic matrix and consequently does not apply to aqueous or air emissions produced by the treatment process. For aqueous streams the guidance provides that they must contain less than 3 ppb PCBs. Releases to air must be less than 10 ug of PCBs per cubic meter. It should be noted that these levels apply to treatment processes only and were not intended to be used as cleanup standards for reentry or reuse.

2.7.2 Verification of PCB Spill Cleanup by Sampling and Analysis (U.S. EPA, 1985b)

This document describes methods for sampling and analyzing PCBs in various media. It also includes basic sampling strategies, identification of sampling locations, and guidance on interpreting sampling results. This manual may be useful in developing sampling plans at Superfund sites and in identifying appropriate methods for complicated sampling, for instance sampling of structures.

2.7.3 Field Manual for Grid Sampling of PCB Spill Sites to Verify Cleanup (U.S. EPA, 1986b)

This manual provides a step-by-step guidance for using hexagonal grid sampling primarily for determining if cleanup levels have been attained at the site. It discusses preparation of the sample design, collection, handling and preservation of the samples taken, maintenance of quality assurance and quality control, and documentation of sampling procedures used. It is a companion to the guidance described in section 2.7.2 that discusses in more detail the rationale and techniques selected. The field manual addresses field sampling only and does not provide information on laboratory procedures. This guidance may be useful in specifying the appropriate sampling after or during remedial action to assess progress toward achieving cleanup goals.

2.7.4 Development of Advisory Levels for PCB Cleanup (U.S. EPA 1986a)

This document provides the basis for the cleanup levels developed in the PCB Spill Policy. It discusses the assumptions made in addressing the dermal contact, inhalation, and ingestion pathways and may provide useful information for completing risk assessments at Superfund sites. An update to the calculations made in this document to account for recent policy on standard ingestion assumptions and revised cancer potency factor for PCBs has been provided in a memorandum (U.S. EPA, 1988d).

2.7.5 Risk Assessment Guidance for Superfund: Human Health Evaluation (RAG) (U.S. EPA, 1989e)

This document describes the human health evaluation process conducted as part of the risk assessment at Superfund sites. It includes standard assumptions for various exposure pathways that have been used to calculate starting point action levels in section 3 of this document.

A second volume, Environmental Evaluation Manual, addressing the environmental evaluation provides general guidelines on considerations pertinent to evaluating the impact of contamination on the environment.

Chapter 3

Cleanup Level Determination

This section describes various scenarios and considerations pertinent to determining the appropriate level of PCBs that can be left in each media that is contaminated to achieve protection of human health and the environment. For soils, the starting point action level (preliminary remediation goal) is 1 ppm for sites where unlimited exposure under residential land use is assumed. Higher starting point values (10 to 25 ppm) are suggested for sites where the exposure scenario is industrial. Remediation goals for ground water that is potentially drinkable should be the proposed MCL of .5 ppb. Cleanup levels associated with surface water should account for the potential use of the surface water as drinking water, impacts to aquatic life, and impacts through the food chain. Occasionally, stormwater runoff to nearby streams can contribute significant environmental or health risks, especially to those eating contaminated fish.

3.1 Soils

The concentration of PCBs in the soil above which some action should be considered (i.e., treatment or containment) will depend primarily on the exposure estimated in the baseline risk assessment based on current and potential future land use. This section has correspondingly been organized according to categories of alternatives differentiated by the expected direct contact that will occur. Other factors influencing the concentration to which soils should be excavated or contained include the impact the residual concentration will have on ground water and potential environmental impacts. Since these pathways are pertinent to all site categories, they are discussed in separate sections. The guideline concentrations provided in this section do not imply that action must be taken at a Superfund site, rather they indicate the area over which some action should be considered once it has been determined that action is necessary to provide protection of human health and the environment.

A summary of the guidelines discussed in this section is presented in Table 3-1.

TABLE 3-1
Recommended Soil Action Levels -- Analytical Starting Points
(Considers ingestion, inhalation, and dermal contact only)

Land Use	PCB Action Levels (ppm)
Residential	1 ppm
Industrial	10 - 25 ppm

These action levels and the assumptions discussed in the following sections can be used to reduce the need for detailed site-specific risk assessments; however, future site uses should be well understood and final cleanup levels must still reflect all relevant exposure pathways and be defensible on a site-specific basis.

The analysis of PCBs is complicated by the fact that there are 209 different PCB compounds[1] (Alford-Stevens, 1986). Common analytical methods are listed in Table 3-2.

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[1] Aracholors are groups of PCBs with different overall percentages of chlorine. For example, Arochlor 1242 contains 42% chlorine made up of tri- and tetra- chlorinated biphenyls. PCB isomers are those compounds that have the same number of chlorine atoms. Individual PCBs isomers, of which there are 209, are called congeners.

3.1.1 Preliminary Remediation Goals for Residential Areas

The concentration that defines the area over which some action must be taken is the concentration of PCBs that can protectively be left on site without management controls. In areas where land use is residential, this concentration will be based on standard assumptions for direct contact -- dermal, ingestion, and inhalation -- and should consider potential impact to ground water, which is discussed in section 3.1.4.

For Superfund sites, the risk remaining after remediation should generally fall within the range of 10^{-4} to 10^{-6} individual excess cancer risk. Based on the standard exposure assumptions associated with residential land use (ingestion, inhalation, and dermal contact), concentrations of .1 ppm PCBs to 10 ppm PCBs will generally fall within the protective range. A concentration of 1 ppm PCBs equates to approximately a 10^{-5} excess cancer risk assuming no soil cover or management controls. The 1 ppm starting point for residential scenarios reflects a protective, quantifiable concentration for soil. Lower concentrations (e.g., reflecting a 10^{-6} risk level) are not generally quantifiable and in many cases will be below background concentrations. (Because of the persistence and pervasiveness of PCBs, PCBs will be present in background samples at many sites.) A concentration of 1 ppm PCBs should therefore generally be the starting point for analysis at PCB-contaminated Superfund sites where land use is residential. Alternatives should reduce concentration to this level or limit exposure to concentrations above this level.

As part of the development of the cleanup levels in the PCB Spill Cleanup Policy, a detailed analysis of the direct contact pathways was performed by the EPA Office of Health and Environmental Assessment (U.S. EPA, 1986a). This analysis was subsequently updated to account for the revised cancer potency factor and ingestion assumptions (U.S. EPA, 1988d). This analysis estimates risk levels associated with various concentrations of PCBs based on physical parameters of PCB 1254. It is also estimated that a 10 inch cover of clean soil will reduce risks by approximately one order of magnitude. Using some of the basic assumptions associated with PCBs (e.g., mobility, volatility, absorption) described in this analysis and the standard exposure assumptions for residential land use presented in the Risk Assessment Guidance (U.S. EPA, 1989e), risk levels associated with various concentrations of PCBs in soil were calculated (see Appendix B). This analysis forms the basis for the

Table 3-2
ANALYTICAL METHODS FOR PCBs

Matrix	Method	GC	GC / MS	Detection Limit[1]	Quantification Limit[2]
Oil	Bellar and Lichtenberg	yes		less than 2 ppm	2 ppm
	ASTM 04059	yes		less than 2 ppm	2 ppm
Soil/ Sediment	Method 680		yes	~ 100 ppb	1 ppm
	Method 608[3,5]	yes		0.1 - 0.5 ppb	80 ppb
Water	EPA Method 505 (Microextraction)	yes		0.1 - 0.5 ppb (based on the arochlor present)	not given
	Method 508A[4] (Perchlorination)			0.1 - 0.5 ppb (as decachlorobiphenyl)	not given
	Method 680		yes	~ 100 ppb	1 ppm
	Method 608[3,5]	yes		0.1 - 0.5 ppb	0.5 ppb
Air	NIOSH Method 5503 Florosil sorbent, hexane extraction, GC/ECD	yes			

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[1] Detection limit indicates the concentration above which the presence of PCBs will be detected by the analytical method.

[2] Quantification limit indicates the concentration above which the quantity of PCBs present can be determined.

[3] U.S. EPA, 1986d.

[4] U.S. EPA, 1988a, Glaser, 1981.

[5] Method 608 depends on the presence of an intact Arochlor. Analysts can estimate possible PCB concentrations when intact Arochlors are not present. However, if this is done the presence of PCBs should be confirmed using Method 680. Method 680 can identify PCB isomers.

analytical starting point summarized here. The primary assumptions and an example calculation for a PCB concentration of 1 ppm are shown in Table 3-3. It should be noted that some of these assumptions may be overly conservative on a site-specific basis. For example, the calculation for the inhalation pathway assumes that someone is on the site 24 hours a day for 30 years and that the concentration of PCBs in the air in a house on this site will be the same as the concentration in the air outside. In many cases, partial covering of the soil will limit the level of PCBs that can volatilize. Another consideration is that the calculation was based on the properties of Arachlor 1254 and properties may vary for different congeners as shown in Table 3-4. Toxicities may also vary (McFarland, 1989; Kimbrough, 1987; Safe, 1985), though there is limited information on this and the toxicity based on Arachlors 1254 or 1260 should generally be used.

As noted above, these calculations reflect direct exposure assumptions only and may not be appropriate where ground water or ecological habitats are potentially threatened. These levels are consistent with the guidance provided by the PCB Spill Cleanup Policy which recommends a 10 ppm cleanup level with a 10 inch cover for residential areas.

3.1.2 Preliminary Remediation Goals for Industrial/Remote Areas

In remote areas or areas where land use is industrial, a more appropriate concentration at which to start analysis may be 10 to 25 ppm, since direct exposure is less frequent than for residential land use and higher concentrations will be protective. (Under the PCB Spill Policy this category includes sites that are more than .1 km from residential/commercial areas or where access is limited by either man-made or natural barriers (e.g., fences or cliffs).) For example, at Superfund sites located in industrial areas ingestion and inhalation exposures are more limited than for a residential area. Even assuming exposure equivalent to that in residential areas, these levels (10 to 25 ppm) are still within the acceptable risk range (approximately 10^{-4}) based on the direct contact exposure pathways, and in fact will reflect a lower risk due to the reduced frequency of exposure expected at the site. This is consistent with the PCB Spill Cleanup Policy which recommends a cleanup level of 25 to 50 ppm for sites in industrial or other reduced access areas.

Table 3-3
PCB DIRECT CONTACT ASSUMPTIONS
(See Appendix B for detailed calculation)

INGESTION:

Soil ingestion (1 to 6 years)	0.2 g/day[1]
Soil ingestion (7 to 24 years)	0.1 g/day[1]
Body weight child	16 kg[1]
Body weight adult	70 kg[1]
Absorption of PCBs from ingested soil	30%[2]

INHALATION

Adult inhalation rate	30 m^3/day[1]
Lung absorption of inhaled PCBs	50%

DERMAL

Surface area (3 - 18 years)	0.4 m^2/event[1]
Surface are (adult)	0.31 m^2/event[1]
Soil to skin adherence factor	2.77 mg/cm$^{2/1}$
Exposure frequency (child)	132 events/year[1]
Exposure frequency (adult)	52 events/year
Adsorption fraction	10%[3]

To estimate exposure, the average concentration of PCBs in soil over the exposure period is calculated. The concentration of PCBs will decrease with time due to volatilization.

EXAMPLE CALCULATION

At 1 ppm PCB initial soil concentration:
Average concentration over 10 inches over 6 years = 0.54 ppm
Average concentration over 10 inches over 30 years = 0.28 ppm

Risk due to soil ingestion = 2 X 10^{-6}
Risk due to inhalation = 7 X 10^{-6}
Risk due to dermal contact = 7 X 10^{-6}
Total risk (all pathways) = 1.6 X 10^{-5}

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[1] U.S. EPA, 1989e
[2] U.S. EPA, 1986a
[3] U.S. EPA, 1986a

Table 3-4
CHEMICAL AND PHYSICAL PROPERTIES OF PCBs

PCB	Molecular Weight	K_{ow}	Specific Gravity	Solubility[a] in Water (mg/l)	Vapor Pressure (mm Hg) at 25°C	Henry's Law Constant (atm-m^3/gmol)
PCB-1016 (Arochlor 1016)	257.9	24,000		0.42	4×10^{-4}	
PCB-1221	200.7	12,000	1.182	15.0	6.7×10^{-4}	
PCB-1232	232.2	35,000	1.266	1.45	4.06×10^{-3}	
PCB-1242	266.5	380,000	1.380	0.24	4.06×10^{-4}	5.73×10^{-4}[b]
PCB-1248	299.5	1,300,000	1.445	5.4×10^{-2}	4.94×10^{-4}	3.51×10^{-3}[b]
PCB-1254	328.4	1,070,000	1.538	1.2×10^{-2}	7.71×10^{-5}	8.37×10^{-3}[c]
PCB-1260	377.5	14,000,000	1.620	2.7×10^{-3}	4.05×10^{-5}	7.13×10^{-3}[c]
PCB-1262			1.646			
PCB-1268			1.810			
PCB-1270			1.947			
PCB-2565			1.727			
PCB-4465			1.712			
PCB-5442			1.434			
PCB-5460			1.740			
2,2',5,5'-Tetrachlorobiphenyl				4.6×10^{-2}		
2,2',3,4,5-Pentachlorobiphenyl				2.2×10^{-2}		

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[a] Hutzinger et al., 1974, Monsanto Chemical Co., undated.
[b] MacKay and Leinonen, 1975.
[c] Hwang, 1982, and U.S. EPA, 1980b.

Bioaccumulation factor: 31,200 L/kg, (U.S. EPA, 1986a)

Soil-water partition coefficient (U.S. EPA, 1980a): 22 - 1938 L/kg.

3.1.3 Assessing the Impact to Ground Water

Generally, PCB soil cleanup levels based on direct contact assumptions will provide sufficient protection of ground water. However, if ground water is very shallow, oily compounds are or were present, or the unsaturated zone has a very low organic carbon content, an additional evaluation of the residual concentration that will not exceed levels found to be protective for ground water should be made.

There are many factors such as soil permeability, organic carbon content, and the presence of organic colloids, which can influence PCB movement from soil into ground water. The situation is complicated by the low solubility of PCBs and the prevalence of their occurrence as solutes in oils. At this point the migration of PCBs to ground water can only be described qualitatively. Table 3-4 lists factors affecting migration for several PCBs.

PCBs are very immobile under conditions where the PCB concentration in the aqueous phase is controlled by the aqueous solubility of PCBs and transport is governed by partitioning between the water and soil. However, low solubility compounds like PCBs may migrate through facilitated transport on colloidal particles (Backhus, 1988) or dissolved in more mobile substances such as oils if present as a separate phase (U.S. EPA, 1989f). Measurements of dissolved organic carbon (DOC) in leachate may help assess this movement since PCBs will sorb to the organic material. Concentrations of PCBs in water samples exceeding PCB water solubility indicate that PCBs are being solubilized by something other than water. PCBs in oils will be mobile if the oil itself is present in volumes large enough to move a significant distance from the source. If immiscible fluid flow is significant, PCB transport predictions must be based on immiscible fluid flow models.

3.2 Ground Water

If PCBs have contaminated potentially drinkable ground water, ground water response actions should be considered. As discussed above, PCBs generally have low mobility but can be transported with oils in which they may be dissolved. A problem that arises is that once the immiscible fluid has been immobilized through capillary retention in the soil pore space (termed the residual saturation), PCB transport is governed by the rate at which the PCBs dissolve from the oil into the water moving past the residually saturated oil. This is a very slow process with the residual saturation serving as a long-term source of contamination.

Emulsification of the residual oil, and PCB transport in micelles may also occur.

PCBs have also been found to migrate within aquifers sorbed to colloidal particles. This movement can be assessed through analyzing both filtered and unfiltered ground water samples for PCBs (U.S. EPA, 1989f and U.S. EPA, 1989g).

In both scenarios described above, PCBs can be found in unfiltered ground water samples at levels that exceed health based concentrations. The proposed MCL for PCBs is .5 ppb reflecting a 10^{-4} excess cancer risk. (Proposed MCLs are considered TBC for ground water that is potentially drinkable.) These situations are also very difficult to address actively. In the first case, residual oil lodged in pore spaces continues to be a source of PCBs and are very difficult to remove through traditional pump and treat methods. In the case of PCBs present on particulates, the rate of removal through ground water extraction may be very limited and substantial amounts of clean water will be affected as it is pulled into the contaminated zone. Because of the technical impracticability of reducing concentrations to health-based levels, remedies designed to prevent further migration of contaminants may be the only viable option for portions of the contaminated ground water. This may involve removing more soluble organics present which increase the mobility of the PCBs present.

3.3 Sediment

The cleanup level established for PCB-contaminated sediment may be based on direct contact threats using exposure assumptions specific to the site if the surface water is used for swimming. More often, the impact of PCBs on aquatic life and consumers of aquatic life will drive the cleanup level. Interim criteria for sediment based on achieving and maintaining WQC in the surface water have been developed for several chemicals (U.S. EPA, 1989a). The approach used to estimate these values is called the Equilibrium Partioning Approach (EP) which is based on two interrelated assumptions. First, that the interstitial water concentration of the contaminant is controlled by partitioning between the sediment and the water at contaminant concentrations well below saturation in both phases. Thus, the partitioning can be calculated from the quantity of the sorbent on the sediment and the appropriate sorption coefficient. For nonpolar organic contaminants, the primary sorbent is the organic carbon on the sediment; therefore, the partition coefficient is called the organic carbon normalized partition coefficient, K_{oc}. Second, the toxicity and the accumulation of the contaminant by benthic organisms is correlated to the interstitial, or pore water concentration and not directly to the total concentration of the contaminant on the sediment.

When the EP approach is used to estimate sediment quality criteria, chronic water quality criteria (WQC) (U.S. EPA 1980c and U.S. EPA 1985a) are used to establish the "no-effect" concentration in the interstitial water. The interstitial water concentration (C_w) is then used with the partition coefficients (K_{oc}) and the following equation:

$$C_{sed} = K_{oc} * C_w$$

to calculate the concentration of the contaminant on the sediment (C_{sed}) that at equilibrium will result in this interstitial water concentration. This concentration on the sediment will be the numerical criteria value (SQC).

Interim sediment quality criteria for PCBs are shown in Table 3-5. These values were derived using the Koc value of 6.14 for PCBs which was estimated using the median of the log mean Kow values for Arochlor 1242. Confidence limits (95%) around this Koc value based on preliminary uncertainty estimates range from 5.44 to 6.85. The WQC concentration of .014 ug/L for freshwater aquatic life (U.S. EPA, 1980b) is derived using the residue value of .64 ug/g from studies with mink and the mean bioconcentration factor for salmonids of 45,000. The WQC concentration of .03 ug/L PCBs for saltwater was not used. Instead, a WQC concentration of .024 ug/L for saltwater was calculated using the FDA Action level of 2.0 ug/g, a mean BCF of 10,400 and a lipid value for benthic species of 8.0 percent. Therefore, the SQC concentrations in Table 3-5 are intended to protect wildlife consumers of freshwater benthic species and the marketability of saltwater benthic species.

To determine if the sediment concentration of a nonpolar contaminant exceeds the sediment criteria values, the concentration of the contaminant and the organic carbon content of the sediment must both be known. Because the sediment criteria values are presented as normalized to organic carbon content (i.e., presented on a per organic carbon weight basis -- ug/gC), the normalized sediment concentrations of the contaminants must be calculated. These normalized concentrations can then be directly compared with the interim values shown in Table 3-5. SQC concentrations do not apply to sediments containing less than 0.5% organic carbon.

If concentrations of PCBs in sediments exceed these SQC values, chemical monitoring of indigenous benthic and water column species should be instituted to determine if prey species of wildlife or marketable benthic or water column species contain unacceptable concentrations of PCBs. Monitoring of indigenous wildlife species will provide insights into actual extent of exposure to PCBs from a specific site relative to reference sites. This is particularly important where the areal extent or the heterogeneity of sediment contamination by PCBs is great and because biomagnification of PCBs in food chains is not considered in deriving the aquatic life WQC concentrations. If chemical monitoring of biota fails to indicate that uses are impaired, the need for extensive remediation based on exceedence of SQC values should be questioned.

TABLE 3-5
PCB Sediment Quality Criteria[1]

	Sediment Quality Criteria (ug/gC)		Sediment Conc. (ug/g)	
WQC - Freshwater	Mean	95% Confid. Int.	OC = 10%	OC = 1%
.014 ug/L	19	3.8 - 99	1.9 (.38 - 9.9)	.19 (.038 -.99)
WQC - Saltwater				
.024 ug/L	33	6.6 - 170	3.3 (.66 -17)	.33 (.066 - 1.7)

[1] Based on Koc = 6.14 (5.44 - 6.85). If these SQC are exceeded chemical monitoring of PCB concentrations in indigenous biota is recommended prior to decisions on ecological risks or remediation. These SQC apply to sediments whose organic carbon (OC) concentrations are greater than .5%.

3.4 Ecological Considerations

The occurrence of PCBs at Superfund sites often poses significant threat to wildlife. Mobility of PCBs into ground water, into air, and through biological vectors can result in adverse ecological impacts beyond the immediate boundaries of the site. It is important to consider interactive ecological processes relative to PCB contamination as part of the remedial investigation. This evaluation can provide insights into other avenues of human exposure in addition to ensuring protection of wildlife.

Assessments of PCB sites by the Department of the

Interior have concluded that PCB concentrations of 1 - 2 ppm will be protective of wildlife such as migratory birds and that providing a soil cover over more highly contaminated areas can further mitigate threats to acceptable levels. However, the uncertainty regarding environmental impacts described below may warrant more in-depth analysis at sites where this pathway may be of particular significance; e.g., sensitive species, high agricultural use.

It may be important to note that, from a toxicological and ecological perspective, not all PCB congeners will have the same effects. Discrimination of congeners appears operative at many physical, chemical, and biological levels: primary source materials differ from environmental samples; toxicity values differ among congeners; persistence in the environment varies; and bioaccumulation potential varies among congeners and across trophic levels. Consequently, an established environmental concentration based on total PCB concentration (i.e., irrespective of the specific congeners) may show little relationship to biological phenomena (e.g., food chain contamination, toxicity, etc.).

Metabolism of PCBs can occur in a diverse group of organisms including bacteria, plants, and animals. (Fungi almost certainly possess similar capabilities.) For the most part the lesser chlorinated congeners are more readily subject to metabolism, whereas the penta-, hexa-, and heptachlorinated forms are quite recalcitrant. Metabolism should not be equated with degradation, because certain conversions are better thought of as modifications of the parent compound; and in some cases the modified forms may become more toxic, more water-soluble, more bioavailable. To date the best evidence for degradation is demonstrated for certain bacteria which are capable of dechlorinating the lesser cholorinated congeners.

Toxicity symptoms are most clearly observed in animals (Focardi, 1989 and Aulerich, 1986). Usually the symptoms are sublethal. Chronic exposures lead to disrupted hormone balances, reproductive failure, teratomas, or carcinomas. Plants do not appear to exhibit detectable toxicity responses to PCBs (Fletcher, 1987a and Fletcher, 1987b).

Biological contamination may occur through a variety of routes. Aquatic organisms may incorporate PCBs from water, sediment, or food items. Subterranean animals, similarly accumulate PCBs via dermal contact and ingestion (Tarradellas, 1982). Exposure scenarios in above-ground terrestrial populations additionally may occur via volatilization. The least understood features of food web contamination are those related to the uptake, fate and transport of PCB congeners in plants.

Chapter 4

Developing Remedial Alternatives

As described in Section 1, one of the Superfund expectations is that principal threats at a site will be treated wherever practicable and that low-threat material will be contained and managed. Treatment and disposal options for PCB contaminated material are governed by the type of material that is contaminated and the concentration of PCBs in the material that is to be disposed. Principal threats will generally include material contaminated at concentrations exceeding 100 ppm or 500 ppm depending on the land use setting. Where concentrations are below 100 ppm (less than 2 orders of magnitude above the starting point action level), treatment is less likely to be practicable unless the volume of contaminated material is relatively low.

The treatment options for contaminated soils and sludges mixed with soil are discussed in this chapter. (Consistent with the Superfund expectations and TSCA requirements, PCB liquids generally will be incinerated. Aqueous PCB streams generally will be treated by traditional treatment systems such as carbon adsorption.) There are three primary options for non-liquid PCBs at concentrations of 50 ppm or greater that are compliant with TSCA ARARs (there is no separate consideration given to non-liquid PCBs at concentrations greater than 500 ppm):

1. Incineration;
2. Treatment equivalent to incineration;
3. Disposal in a chemical waste landfill.

There are additional options for addressing PCB contaminated dredged material. Superfund expectations indicate that innovative treatment methods should be considered where they offer comparable or superior treatment performance, fewer/lesser adverse impacts, or lower costs than more demonstrated technologies. For PCBs, possible innovative technologies meeting these criteria include solvent extration, KPEG, biological treatment, and in-situ vitrification.

For low-threat material that is contained and managed in place over the long term, appropriate engineering and institutional controls should be used to ensure protection is maintained over time. An initial framework for determining appropriate long-term management controls is provided in Table 4-2. As indicated by this table, institutional controls alone are not sufficient to provide protection except in cases where the concentrations remaining are low and the expected land use is industrial.

4.1 Identifying Principal Threats/Low-Threat Areas

The process for developing alternatives at Superfund sites with PCB contamination described below is outlined in the flow chart in Figure 4-1.

Once the area over which some action must be taken to reduce risks has been identified; i.e., areas contaminated above 1 ppm PCBs (residential) or areas contaminated above 10 - 25 ppm PCBs (industrial), the wastes comprising the principal threat at the site should be identified. These wastes will include soil contaminated at 2 to 3 orders of magnitude above the action level. For sites in residential areas, principal threats will generally include soils contaminated at concentrations greater than 100 ppm PCBs. For sites in industrial areas, PCBs at concentrations of 500 ppm or greater will generally constitute a principal threat. Consistent with Superfund expectations, the principal threats at the site should be treated. Treatment methods are described in Section 4.2.

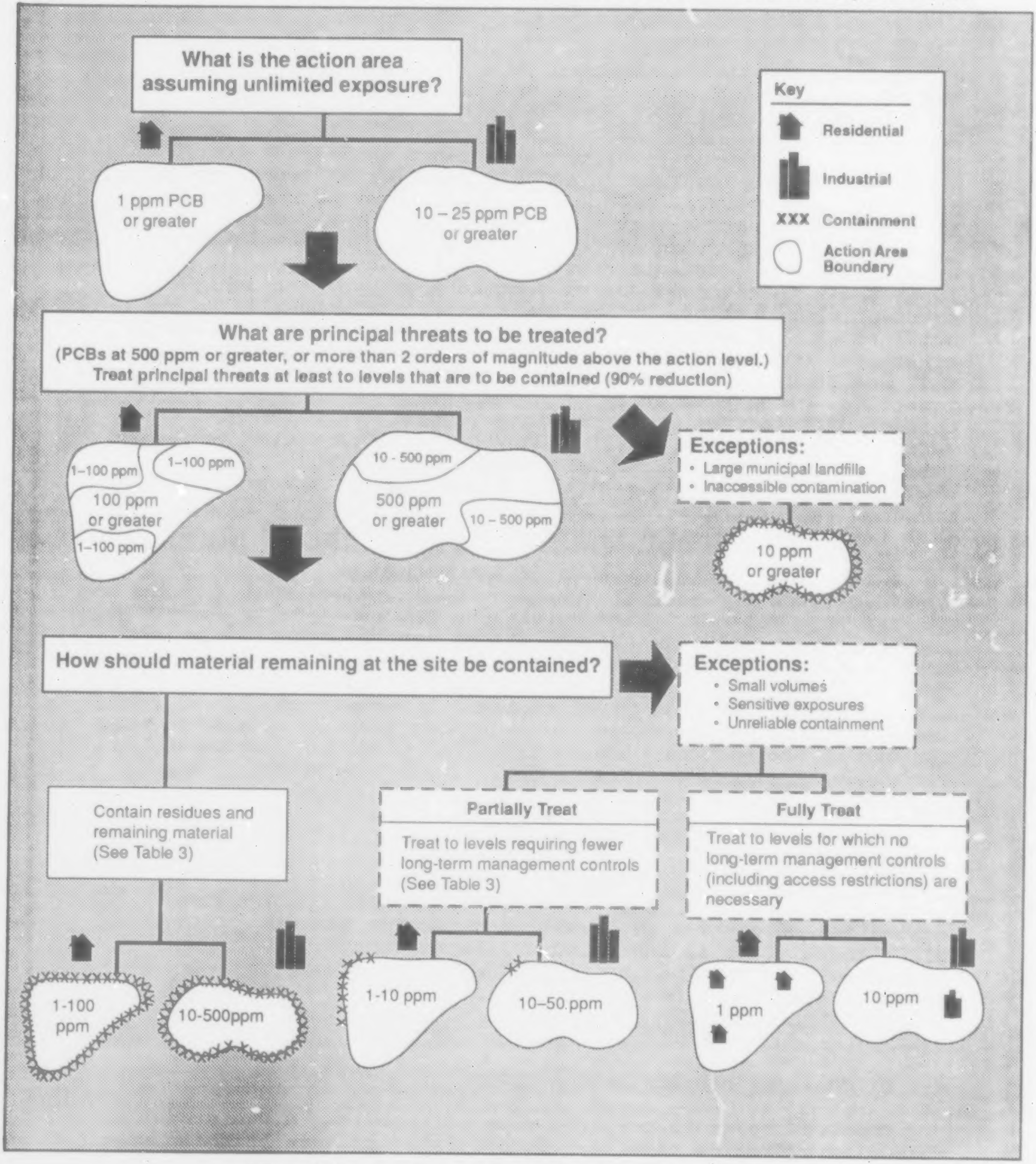
In some cases, it may be appropriate to treat material contaminated at concentrations lower than what would otherwise define the principal threats because it is cost effective considering the cost of treatment verses the cost of containment, because the site is located in a sensitive area such as a wetland, or because the site is located in an area where containment is unreliable such as a floodplain. In other cases, it may be appropriate to contain the principal threats as well as the low-threat material because there are large volumes of contaminated material, because the PCBs are mixed with other contaminants that make treatment impracticable, or because the principal threats are not accessible; e.g., sites where they are buried.

Material that is not treated but is above actions levels should be contained to prevent access that would result in exposures exceeding protective levels. A framework of long-term management controls for various site scenarios is provided in section 4.3.

4.2 Treatment Methods

Several methods have been used or are currently being evaluated to reduce the toxicity, mobility, or volume of PCB-contaminated material. Depending on the volume of material to be treated, the other contaminants that may be present, and the consistency of the contaminated material, one or more of these methods should be considered as options for addressing the principal threats.

Figure 4-1 – Key Steps in the Development of Remedial Alternatives for PCB-Contaminated Superfund Sites*


What is the action area assuming unlimited exposure?
Key
Residential
Industrial
XXX Containment
Action Area Boundary
1 ppm PCB or greater
10 – 25 ppm PCB or greater
What are principal threats to be treated?
(PCBs at 500 ppm or greater, or more than 2 orders of magnitude above the action level.)
Treat principal threats at least to levels that are to be contained (90% reduction)
1–100 ppm
1–100 ppm
100 ppm or greater
1–100 ppm
10 - 500 ppm
500 ppm or greater
10 – 500 ppm
Exceptions:
• Large municipal landfills
• Inaccessible contamination
10 ppm or greater
How should material remaining at the site be contained?
Exceptions:
• Small volumes
• Sensitive exposures
• Unreliable containment
Contain residues and remaining material (See Table 3)
Partially Treat
Treat to levels requiring fewer long-term management controls (See Table 3)
Fully Treat
Treat to levels for which no long-term management controls (including access restrictions) are necessary
1-100 ppm
10-500ppm
1-10 ppm
10–50 ppm
1 ppm
10 ppm

* These numbers are guidance only and should not be treated as regulations.

In addition to incineration, there are several other technologies that result in the destruction or removal of PCBs in contaminated soil. These methods can be used with no long-term management of treatment residuals if they can be shown to achieve a level of performance equivalent to incineration, as required in 40CFR761.60(e). As described in guidance (U.S. EPA, 1986c), this determination can be made by demonstrating that the solid treatment residuals contain less than or equal to 2 ppm PCBs using a total waste analysis. When a remedial action alternative for a Superfund site involves use of a technology that can achieve substantial reductions but residual concentrations will still exceed 2 ppm, the alternative snould include long-term management controls as outlined later in Table 4-2. This will not be considered equivalent treatment but will be treated as closure of an existing hazardous waste unit consistent with TSCA chemical waste landfill requirements (RCRA closure - 40CFR 264.301 and TSCA chemical waste landfill - 40CFR 761.75). As described in Table 4-2, certain long term management controls may be waived using the TSCA waiver provision, depending on the concentration of PCBs remaining and other site-specific factors.

A brief discussion of some of the pertinent considerations for several treatment technologies that address PCBs follows. The evaluations described below provide the substantive considerations pertinent to treatment of PCBs on Superfund sites. When material is transported off-site for treatment, the treatment facility must be permitted under TSCA. Table 4-1 summarizes important considerations and consequences associated with the use of the various technologies that should be accounted for in developing and evaluating alternative remedial actions.

4.2.1 Incineration

Incineration, covered in 40CFR761.70, should achieve the equivalent of six 9's (99.9999%) destruction removal efficiency. This is indicated by the requirement that mass air emissions from the incinerator stack shall not be greater than .001 g PCB/kg of PCB contaminated material fed into the incinerator.

4.2.2 Chemical Dechlorination (KPEG)

Chemical reagents prepared from polyethylene glycols and potassium hydroxide have been demonstrated to dechlorinate PCBs through a nucleophilic substitution process. Studies

Table 4-1
PCB TREATMENT METHODS AND APPLICATION CONSEQUENCES

Methods	Considerations/Consequences
Incineration	• Cost • Residual disposal (ash, scrubber water) • Public resistance
Biological Treatment	• Efficiency • By-products • Treatment time • Not proven effective for all PCB congeners
Solidification	• Volatilization • Leachability • Physical strength • Life of composite's integrity
Vitrification	• Cost • Volatilization • Leachability
KPEG (Potassium Polyethylene Glycolate)	• Cost (varies with reagent recycleability)* • Efficiency (varies with Arochlor type) • Aqueous wastes must be dewatered either as a pre-step or in a reactor
Solvent Washing/Extraction	• Volatilization of solvent • Solvent recovery • Inability of solvent to extract all PCBs • Several extraction steps • Solvent residual remains in extracted soil • Extracts require destruction via other methods
Granular Activated Carbon	• Removal efficiency in soil has not been established • Spent carbon requires treatment/disposal

have shown that the products of the reaction are non-toxic, non-mutagenic, and non-bioaccumulative (desRosiers, 1987). Treatability studies in Guam and at the Wide Beach Superfund Site in New York have shown that PCB concentrations can be reduced to less than 2 ppm. However, variable concentrations in material to be treated will result in varying efficiencies of the treatment system and systems must be monitored carefully to ensure that sufficient reaction time is allowed.

This technology can achieve performance levels that are considered equivalent to incineration; however, treatability studies generally will be required to demonstrate that the concentration reductions can be achieved on a consistent basis for the material that is to be treated. In some cases, cost-effective use of the KPEG process will result in substantial reductions of PCB concentrations, but the residual levels may still be above 2 ppm, in which case chemical waste landfill requirements will also need to be met.

4.2.3 Biological Treatment

Some work has been done on the use of microbes to degrade PCBs either through enhancing conditions for existing microbes or mixing the contaminated material with engineered microbes (Quensen, 1988; Bedard, 1986; Unterman, 1988; Abramowicz, 1989). The use of this process requires detailed treatability studies to ensure that the specific PCB congeners present will be degraded and that the byproducts of the degradation process will not be toxic. For in-situ application, it is possible that extensive aeration and nutrient addition to the subsurface will increase the mobility of PCBs through transport on particulates. This phenomenon should be considered when potential ground water contamination is a concern.

In-situ application does not trigger TSCA requirements (unless disposal occurred after February 17, 1978) and the primary consideration should be attainment of cleanup levels established for the site based on the evaluation of factors described in Chapter 3. Biological processes involving the excavation of contaminated material for treatment in a bioreactor that can be shown to achieve residual concentrations of less than or equal to 2 ppm PCBs can be considered equivalent treatment. Treatment residuals can be re-deposited on site without long-term management controls as long as treatment byproducts do not present a threat to human health and the environment.

4.2.4 Solvent Washing/Extraction

Solvent washing/extraction involves removing PCBs from excavated contaminated soil and concentrating them in a residual side stream that will require subsequent treatment, generally incineration. Often the solvent can be recovered by taking advantage of certain properties of the solvent being used. Aliphatic amines (e.g., triethylamine [TEA]), used in the Basic Extractive Sludge Treatment (B.E.S.T.), exhibit inverse miscibility. Below 15 degrees C, TEA can simultaneously solvate oils and water. Above this temperature, water becomes immiscible and separates from the oil and solvent. Consequently, a process can be designed to remove water and organics at low temperatures, separate the water from the organic phase at higher temperatures, and recover most of the solvent through distillation. The high concentration PCB stream is then typically incinerated.

A similar process, called critical fluid extraction, involves taking advantage of increased solvent properties of certain gases (e.g., propane) when they are heated and compressed to their "critical point." Once the PCBs have been extracted, the pressure can be reduced allowing the solvent to vaporize. The solvent can be recovered and the remaining PCBs sent to an incinerator.

Treatability tests run to date have indicated that there is probably a limit to the percentage reduction (on the order of 99.5%) achievable with these processes. Repeat applications can increase the reductions obtained and studies have shown that PCB concentrations in the extracted soil of less than 2 ppm can be achieved. However, it may not be cost-effective for sites where there are large volumes of material at very high concentrations.

4.2.5 Solidification/Stabilization

The terms solidification and stabilization are sometimes used interchangeably, however, subtle differences should be recognized. Solidification implies hardening or encapsulation to prevent leaching, whereas stabilization implies a chemical reaction or bonding to prevent leaching. Solidification of PCBs can be accomplished by use of pozzolons such as cement or lime. Encapsulation, rather than bonding, occurs to prevent leaching of the PCBs. There is some evidence in the literature that the excess hydroxides are substituted on the biphenyl ring resulting in a dechlorination reaction (U.S. EPA, 1988c). The dechlorinated product would probably be less toxic than the parent molecule. Stabilization may be accomplished using a modified clay or other binder to bond to the PCB preventing leaching of the PCBs even under extreme environmental conditions. This product will probably be stable over time because of the binding, but no changes in the parent molecules are expected.

To assess the reduction in mobility achieved through solidification, leaching analysis, such as the Toxicity Characteristic Leaching Procedure (TCLP), should be performed before and after solidification. Since PCB migration potential is reduced but the PCBs are still present in the waste and the long term reliability of the treatment process is uncertain, long-term management controls as outlined in Table 4-2, based on the concentration of PCBs stabilized or up to a factor of 10 lower (based on the results of the performance evaluation), should be incorporated into the alternative.

4.2.6 Vitrification

Vitrification involves the use of high power electrical current (approximately 4 MW) transmitted into the soil by large electrodes which transform the treated material into a pyrolyzed mass. Organic contaminants are destroyed and/or volatilized, and inorganic contaminants are bound up in the glass-like mass that is created. Volatilized organics must be captured and treated. Since this process is often performed in-situ without disturbing the contaminated material, the requirements of TSCA would not be applicable unless disposal occurred after February 17, 1978. Also, it is often advantageous to consolidate contaminated material into one area for purposes of applying the process in which cases TSCA requirements would apply for PCBs at concentrations greater than 50 ppm since this movement constitutes disposal. Because the process results in complete pyrolosis of the PCBs in the affected area it is considered equivalent to incineration and no long-term management would be warranted based on the PCBs. The perimeter of the treated area should be tested using the TCLP to determine if long term management controls are warranted in areas where gradations in temperature resulted in lower levels of PCB destruction.

4.3 Determining Appropriate Management Controls for Areas Where Concentrations Are Above the Action Levels

Consistent with the Superfund expectations low-threat material should generally be contained on site. As described above, this will generally include soil with PCBs at concentration of less than 100 ppm (residential) or PCBs at concentrations of less than 500 ppm (industrial). The management controls that should be implemented for the material that remains at these sites above the action level will depend on the material that is to be contained and hydrogeological and meteorological factors associated with the site. Controls may include caps, liners, leachate collection systems, ground water monitoring, surface water controls, and site security. A general framework of appropriate controls under various site scenarios is provided in Table 4-2. If disposal of PCBs subject to TSCA (concentrations greater than 50 ppm) occurred after 1978, then the long-term management controls required for chemical waste landfills must be addressed for material that is not incinerated or treated by an equivalent method. As noted in the Table, where low concentrations of PCBs will remain on site and direct contact risks can be reduced sufficiently, minimal long term management controls are warranted. Controls should ensure that PCBs will not pose a threat to the ground water or any nearby surface water. TSCA waivers of particular chemical waste landfill requirements may be justified. Where TSCA landfill requirements are not applicable (post-78 disposal of >50 ppm PCB material did/does not occur), they will not be relevant and appropriate since RCRA closure requirements are generally the relevant ant appropriate requirement; consequently, the use of the TSCA waiver provision will not be necessary.

4.3.1 Example Analyses -- Long-Term Management Controls

To illustrate the process of determining the appropriate long-term management controls for low-threat PCB contamination that will remain at a site, an example was developed. A description of the models used in this evaluation is provided in Appendix C. The parameters used in this analysis are generally conservative. They are summarized in Table 4-3. Four different source area PCB concentrations were evaluated: 5 ppm, 20 ppm, 50 ppm, and 100 ppm.

The determination of the appropriate long term management controls for this example site was based on preventing access to concentrations of PCBs exceeding the action level (residential, 1 ppm; industrial 10 - 25 ppm) and preventing migration of PCBs to the ground water at concentrations that exceed the proposed drinking water standard -- .5 ppb. The migration to ground water pathway was assessed by determining the infiltration projected through four different cap designs and then modeling the migration of PCBs from the source area to and into the ground water.

Table 4-2 – Selection of Long-Term Management Controls To Be Considered for PCB-Contaminated Sites

PCB - CONCENTRATION (ppm)	APPROXIMATE DEPTH TO GROUND WATER	ACCESS	RCRA COROLLARY	LONG-TERM MANAGEMENT CONTROLS RECCOMENDED							CHEMICAL WASTE LANDFILL REQUIREMENTS						POTENTIAL BASIS FOR TSCA WAIVER (761.75 (c) (4)) OF INDICATED CHEMICAL WASTE LANDFILL REQUIREMENT(S)
				Cover System [1]	Leachate Collection	Leak Detection	Bottom Liner	Ground Water Monitoring	Surface Water Monitoring	Surface Water Management	Bottom Liner	Depth to Ground Water	Ground Water Monitoring	Leachate Collection	Surface Water Monitoring	Fence	
≤ 1	All Depths	• Nonrestricted Access	Clean Closure														No waivers required; clean closure
1-10	All Depths	• Nonrestricted Access	Hybrid Closure	2							X	3	X	X	X	X	Low PCB concentration Design and installation of a protective cover system Evaluation of PCB migration to GW and SW
10-25	All Depths	• Limited Access • Deed Notice	Hybrid Closure	2							X	3	X	X	X	X	Low PCB concentration Design and installation of a protective cover system Evaluation of PCB migration to GW and SW
25-100	All Depths	• Restricted Access • Fence • Deed Notice	Landfill Closure	X				X		4	X	3		X	X		Relatively low PCB concentration Implementation of a GW monitoring program Evaluation of PCB migration to GW and SW Design and installation of a protective cover system
100-500	3-50 Feet	• Restricted Access • Fence • Deed Notice	Landfill Closure	X				X	X	4	X	X		X			Implementation of GW monitoring program Design and installation of a protective cover system Evaluation of PCB migration to GW and SW
	> 50 Feet	• Restricted Access • Fence • Deed Notice	Landfill Closure	X				5	X	4	X		X	X			Design and installation of a protective cover system Demonstrate sufficient depth to GW to protect human health and the environment Evaluation of PCB migration to GW and SW
> 500	3-50 Feet	• Restricted Access • Fence • Deed Notice	Landfill Closure Minimum Technology	X	X	X	X	X	X	4		X					Demonstrate other long-term management controls will provide adequate protection of GW
	> 50 Feet	• Restricted Access • Fence • Deed Notice	Landfill Closure Minimum Technology	X	X	X	X	X	X	4	X			X			Demonstrate sufficient depth to GW and long-term management controls to protect human health and the environment Implementation of GW monitoring program Evaluation of PCB migration to GW and SW

GW = ground water; SW = surface water

[1] Cover system may range from 12" soil cap for low concentrations to a full RCRA cap for concentrations exceeding 500 ppm.

[2] The need for a cover system will depend on the land use (i.e., residential or industrial).

[3] 40 CFR 761.75(b)(3) requires that landfills be located at least 50 feet above the high-water table.

[4] In accordance with 40 CFR 761.75(b)(4) if the site is located below the 100-year floodwater elevation, diversion dikes shall be constructed around the perimeter of the landfill site with a minimum height equal to 2 feet above the 100-year floodwater elevation. Flood protection for landfills above the 100-year floodwater elevation is not applicable to closed landfill units.

[5] When the site is located in a permeable formation, incorporation of this long-term management control should be evaluated.

Table 4-3
SITE PARAMETERS

Source Area--5 Acres
Average Regional Flow 310 ft/year
Porosity of Soil--0.25
Bulk Density of Soil--1.97 g/ml
Time--Peak 70 years from 0-10,000 years
Contaminated zone organic content--5.0%
Clean unsaturated zone organic content--0.5%
Saturated zone organic content--0.1%
PCB half-life--50 years
Depth of Contamination--10 feet
Depth to Groundwater--20 feet
Thickness of Saturated Zone--5 feet

The four caps evaluated in this analysis are:

1. Twelve-inch soil cap
2. Twelve-inch soil cap with 24-inch clay layer
3. 24-inch soil cap, flexible membrane liner, and 12-inch cover soil, and
4. RCRA minimum technology cap including 24-inch soil cap, 12-inch sand drainage layer, flexible membrane liner, 24-inch clay layer, and 12-inch cover soil.

These caps are pictured in Figure 4-2. The infiltration expected through each of these caps, presented in Table 4-4, (given the site conditions presented in Table 4-3) was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) model and the migration of PCBs to and into the ground water was estimated using a combination of a one-dimensional unsaturated zone finite-element flow and transport module called VADOFT (U.S. EPA, 1989f) and an analytical solute/heat transport module called AT123D (Yeh, 1981).

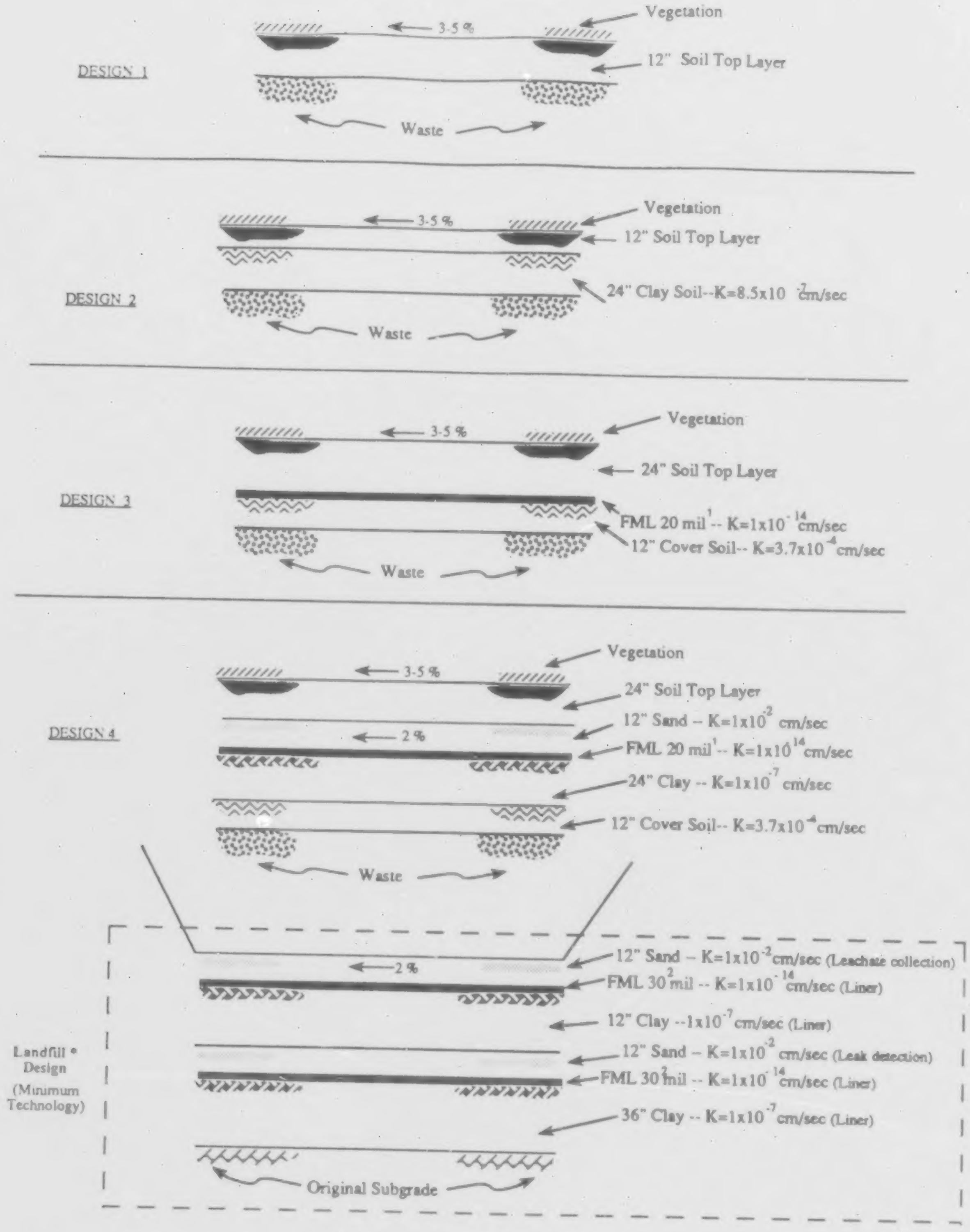
The results of this analysis are summarized in Table 4-5. PCB concentrations in ground water were estimated for each of the four cap designs and four different PCB source concentrations. Based on this analysis, the following recommendations for caps would be made:

5 ppm PCBs Source At this concentration the threat of PCB migration to ground water at concentrations that would exceed the proposed MCL of .5 ppb under the given site conditions is unlikely. The maximum concentration averaged over 70 years (occuring after 945 years) is .099 ppb with only a soil cap. The soil cover would be recommended for sites in residential areas to prevent contact with concentrations above 1 ppm, the starting point action level.

20 ppm PCBs Source Again, the analysis indicates that the threat to ground water is not significant. With only a soil cap, the maximum concentration expected is .4 ppb. For sites in residential areas, a cement cover and a deed notice may be warranted to prevent contact with PCBs exceeding the 1 ppm starting point action level.

50 ppm PCBs Source At 50 ppm, PCB concentrations in the ground water are projected to exceed the .5 ppb level slightly -- approximately 1 ppb. At this concentration, for the site conditions presented, cap design 2 (Figure 4-2) would be recommended. The combination of a low-permeability cover soil and the soil cap will prevent PCBs from migrating to the ground water at levels that exceed .5 ppb. With the reduced infiltration the maximum PCB concentration projected for the ground water (occurring after 1645 years) is .3 ppb. Again, a deed notice would be warranted to prevent direct

Figure 4-2
Cap Design Details


DESIGN 1
3-5 %
Vegetation
12" Soil Top Layer
Waste
DESIGN 2
3-5 %
Vegetation
12" Soil Top Layer
24" Clay Soil--K=8.5x10^{-7} cm/sec
Waste
DESIGN 3
3-5 %
Vegetation
24" Soil Top Layer
FML 20 mil[1]-- K=1x10^{-14}cm/sec
12" Cover Soil-- K=3.7x10^{-4}cm/sec
Waste
DESIGN 4
3-5 %
Vegetation
24" Soil Top Layer
12" Sand -- K=1x10^{-2} cm/sec
2 %
FML 20 mil[1]-- K=1x10^{14}cm/sec
24" Clay -- K=1x10^{-7} cm/sec
12" Cover Soil-- K=3.7x10^{-4}cm/sec
Waste
2 %
12" Sand -- K=1x10^{-2}cm/sec (Leachate collection)
FML 30[2]mil -- K=1x10^{-14}cm/sec (Liner)
12" Clay --1x10^{-7}cm/sec (Liner)
12" Sand -- K=1x10^{-2} cm/sec (Leak detection)
FML 30[2]mil -- K=1x10^{-14}cm/sec (Liner)
36" Clay -- K=1x10^{-7} cm/sec (Liner)
Original Subgrade
Landfill *
Design
(Minimum
Technology)

* RCRA Minimum Technology Landfill bottom liner design for remedial actions requiring RCRA landfill construction.

Table 4-4
COVER DESIGN SUMMARY TABLE (ANNUAL VALUES)

Cover Design	Site Area (Acres)	Precip. (Cu.Ft.)	Runoff (Cu. Ft.)	Evapotrans. (Cu. Ft.)	Infiltration (Cu. Ft.)/ Acre
1	2	258,877	3,349	113,134	71,467
2	2	285,877	78,164	114,628	33,529
3	2	258,877	127,318	131,170	226
4	2	285,877	94,262	118,162	1

Table 4-5
SATURATED ZONE DEPTH AND TIME AVERAGED CONCENTRATIONS BENEATH THE SOURCE (PPB) AND TIME OF PEAK CONCENTRATION (YEARS)

Soil Concentration 5 ppm				Soil Concentration 20 ppm				Soil Concentration 50 ppm				Soil Concentration 100 ppm				T_{Peak} (Years)			
Cap Design 1	Cap Design 2	Cap Design 3	Cap Design 4	Cap Design 1	Cap Design 2	Cap Design 3	Cap Design 4	Cap Design 1	Cap Design 2	Cap Design 3	Cap Design 4	Cap Design 1	Cap Design 2	Cap Design 3	Cap Design 4	Cap Design 1	Cap Design 2	Cap Design 3	Cap Design 4
099	029	0.0	0.0	396	116	0.0	0.0	990	290	0.0	0.0	1.98	580	0.0	0.0	945	1645	--	--

contact with the soil in the future.

100 ppm PCBs Source At 100 ppm, PCB concentrations in the ground water are projected to exceed the .5 ppb level slightly -- approximately .6 ppb, even with the addition of a low-permeability cover soil. At this concentration, for the site conditions presented, the cap design 3 (Figure 4-2) would be recommended. The addition of a flexible membrane liner reduces infiltration sufficiently to prevent migration of PCBs to the ground water. Consistent with Table 4-2, a deed notice, fence, and periodic ground water monitoring would also be recommended.

4.4 Dredged Material

A special allowance is made under TSCA for dredged material and municipal sewage treatment sludges in section 761.60(a)(5)(iii). If, based on technical, environmental, and economic considerations, it can be shown that disposal in an incinerator or chemical waste landfill is not reasonable or appropriate and that an alternative disposal method will provide adequate protection to health and the environment, this alternate disposal method will meet the substantive requirements of TSCA. Since these showings are integral components of any remedy selected at a Superfund site, Superfund actions involving PCB-contaminated dredged material generally will be consistent with TSCA.

4.5 RCRA Hazardous Waste

As noted in section 2.3.2, special consideration must be given to PCB-contaminated soil that also contains material considered hazardous under RCRA. Soil containing constituents that make it hazardous under RCRA that is excavated for the purpose of treatment or disposal must be treated consistent with the land disposal restrictions prior to placement and residuals managed in accordance with Subtitle C closure requirements. This means that a specific treatment method must be applied, or specified concentration levels must be attained for the waste contained in the soil, or a treatability variance must be obtained to establish alternate treatment standards. For soil and debris from CERCLA sites the need for a treatability variance is presumed (preamble to NCP, 55 Federal Register 8760-61, March 8, 1990). Treatment guidelines for constituents found in RCRA hazardous waste have been developed for use in treatability variances and should be used as a guide in determining the reductions in contaminant levels that should be attained by alternative treatment methods.

PCBs alone are not considered hazardous under RCRA since they are addressed under the TSCA regulations; however, land disposal restrictions do address PCBs under the California List Waste provisions for cases where PCBs are mixed with a waste that is considered hazardous under RCRA. If the waste is hazardous under RCRA, and the concentration of halogenated organic compounds exceeds 1000 ppm, the land disposal restrictions associated with California List Waste become applicable. A list of compounds regulated under the category of halogenated organic compounds is provided in 40 CFR part 268 Appendix III. PCBs are included on this list. Soil with HOCs exceeding 1000 ppm that is also considered hazardous under RCRA, must be incinerated or treated under a treatability variance. Under a treatability variance, treatment should achieve residual HOC concentrations consistent with the levels specified for a treatability variance for Superfund soil and debris. PCB concentrations must be reduced to .1 - 10 ppm for concentrations up to 100 ppm, and percent reductions of 90 - 99.9% must be achieved for higher concentrations (U.S. EPA, 1989h). If solidification is used, the levels specified under treatability variance guidelines apply to leachate obtained from application of the Toxicity Characteristic Leaching Procedure (TCLP).

The implications of the land disposal restrictions vary somewhat depending on whether the waste present is a listed hazardous waste or is hazardous by characteristic. If the soil contains a listed hazardous waste, once treatment consistent with the land disposal restrictions (i.e., specified treatment or concentration reductions consistent with the levels provided in the treatability variance guidelines for soil and debris) is employed, the residual after treatment must be disposed of in a landfill that meets the requirements of a RCRA Subtitle C Landfill. It may be possible to delist the residuals to demonstrate that it is no longer hazardous; this may be done for wastes on-site as part of the ROD; for wastes to be sent off-site, EPA Headquarters should be consulted regarding de-listing. If the concentration of PCBs remaining still exceeds 2 ppm, the landfill should also be consistent with a chemical waste landfill described under TSCA. As discussed in Section 4.3, fulfillment of RCRA Subtitle C Landfill Closure requirements will also guarantee fulfillment of TSCA chemical waste landfill requirements.

If the soil contains material that makes it hazardous because of a characteristic; e.g., leachate concentrations exceed levels specified in 40 CFR 261.24, the soil should be treated to established BDAT levels, if any; if BDAT concentrations are not specified, the soil should be treated such that it no longer exhibits the characteristic. Once the BDAT level is achieved (if any) or the characteristic has been removed, it may be possible to land dispose the waste and Subtitle C landfill requirements would not be applicable but rather, the waste would be considered a solid waste and governed by Subtitle D. However, when PCBs are present in the waste, long term management controls consistent with the guidelines given in Section 4.2 should be employed.

4.6 Example Options Analysis -- Contaminated Soil

Table 4-6 outlines the ARARs that may have to be addressed for wastes with different constituents including those that will make the waste hazardous because either a listed waste is present or the material exhibits a hazardous characteristic.

Table 4-6
EXAMPLE PCB COMPLIANCE SCENARIOS FOR CONTAMINATED SOIL

Waste Type and Concentration	Restriction(s) in Effect	Compliance Options to Meet Restrictions *
PCBs > 50 ppm	TSCA	• Dispose of in chemical waste landfill; • Incinerate; or • Use equivalent treatment to 2 ppm (solid residue) or 3 ppb (aqueous phase)
PCBs > 50 ppm, RCRA listed waste, and HOCs < 1,000ppm [in this case PCBs not covered by RCRA]	TSCA	• Must also be consistent with chemical waste landfill if final PCB concentration exceeds 2 ppm (solid residue)
	RCRA LDRs	• Treat to LDR treatment standard for listed waste; or • Obtain an equivalent treatment method petition; or • Obtain a treatability variance (soil and debris concentration levels as TBC); and • Dispose of according to Subtitle C restrictions
PCBs > 50 ppm, RCRA listed waste, and HOCs > 1,000 mg/kg	TSCA	• Dispose of in chemical waste landfill if final PCB concentration exceeds 2 ppm (solid residue)
	RCRA LDRs	• Treat to LDR PCB (i.e., incinerate) and listed waste treatment standard; or • Obtain an equivalent treatment method petition; or • Treat to treatability variance levels for Superfund soil and debris; and • Dispose of according to Subtitle C restrictions
PCBs > 50 ppm, RCRA characteristic metal waste, and HOCs < 1,000 mg/kg	TSCA	• Dispose of in chemical waste landfill if final PCB concentration exceeds 2 ppm (solid residue)
	RCRA LDRs	• Treat to BDAT or Treatability Variance levels and dispose according to Subtitle C restrictions • Solidify to remove characteristic (based on TCLP) and dispose according to Subtitle D restrictions
PCBs > 50 ppm, RCRA characteristic metal waste, and HOCs > 1,000 ppm	TSCA	• Dispose of in chemical waste landfill if PCB concentration exceeds 2 ppm (solid residue)
	RCRA LDRs	• Incinerate to LDR treatment standard for HOCs, solidify ash; or • Treat by equivalent method, solidify; or • Treat to treatability variance levels for PCBs in soil and debris • Treat residuals to meet BDAT/Treatability Variance and dispose according to Subtitle C or remove characteristic and dispose according to Subtitle D restrictions

Chapter 5

Analysis of Alternatives and Selection of Remedy

Consistent with program expectations, it will generally be appropriate to develop a range of alternatives for sites with PCB contamination, including alternatives that involve treatment of the principal threats using methods described in chapter 4 or more innovative methods in combination with long-term management of low-threat wastes consistent with the framework provided. As described in the Guidance on Conducting Remedial Investigations/ Feasibility Studies Under CERCLA, alternatives are initially screened on the basis of effectiveness, implementability, and cost (order of magnitude). Those alternatives that are retained are analyzed in detail against the nine evaluation criteria.

5.1 Evaluating Remedial Alternatives

The overall response options at any site range from cleaning up the site to levels that would allow it to be used without restrictions to closing the site with full containment of the wastes. Alternatives retained for detailed analysis are evaluated on the basis of the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The sections that follow will discuss in turn the first seven of these criteria and the special considerations that may be appropriate when PCB contamination is to be addressed. State and community acceptance are important criteria but are generally handled no differently for PCB sites than they are for other contaminated sites.

5.1.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is achieved by eliminating, reducing, or controlling site risks posed through each pathway. As covered in section 3, this includes direct contact risks, potential migration to ground water, and potential risks to ecosystems. Often alternatives will involve a combination of methods (e.g., treatment and containment) to achieve protection. In general, remedies for PCB sites will involve reducing high concentrations of PCBs through treatment and long-term managment of materials remaining. The methods of protection used to control exposure through each pathway should be described under this criterion.

5.1.2 Compliance With ARARs

As outlined in section 2, the primary ARARs for alternatives addressing PCB contamination derive from the TSCA and the RCRA, and for actions involving PCB contaminated ground water and/or surface water, the SDWA and the CWA.

Since RCRA closure requirements are generally relevant and appropriate at Superfund sites even when a hazardous waste is not involved, a discussion of the measures taken at the site for the alternative being considered that are consistent with the RCRA requirements is warranted.

TSCA is applicable where disposal occurred after February 17, 1978 including any alternatives involving movement of material with 50 ppm or greater PCBs and compliance with the substantive requirements must be addressed. For alternatives that do not achieve the standards specified for treatment of PCBs under TSCA, consistency with long-term management controls associated with a chemical waste landfill must be demonstrated. Consistency may be achieved by complying with the specified landfill requirements or meeting the substantive findings to support a waiver as provided in the TSCA regulations (40 CFR 761.75).

Although the PCB Spill Policy is not ARAR, it is an important TBC. A statement indicating the relationship between the cleanup levels selected and the cleanup levels in the Spill Policy for alternatives involving no or minimal long term management controls is usually warranted.

Because PCBs adhere strongly to soil, it may be impracticable to reduce concentrations in the ground water to the proposed MCL level of .5 ppb throughout the entire plume, for sites where PCBs have migrated to the saturated zone. PCBs adsorbed to particulates can be removed in extraction wells; however, they will be drawn through the aquifer very slowly. A waiver from State standards or the MCL once it becomes final may be warranted for sites where ground water restoration time frames are estimated to be very long or where cleanup cannot be achieved throughout the entire area of attainment. Interim remedies (extraction for a specified period of time such as 5 years) to assess the practicability of extraction or other techniques may be worthwhile to determine the feasibility of achieving drinking water levels or at a minimum, reducing risks to the extent practicable.

5.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence addresses how well a remedy maintains protection of human health and the environment after remedial action objectives have been met. Alternatives that involve the removal or destruction of PCBs to the extent that no access restrictions are necessary for protection of human health and the environment provide the greatest long-term effectiveness and permanence. The uncertainty associated with achieving remediation goals for the treatment methods considered may distinguish alternatives with respect to this criterion. Alternatives that limit the mobility of PCBs through treatment such as solidification/stabilization afford less long-term effectiveness and permanence than alternatives that permanently destroy the PCBs, although solidification in combination with management controls can be very reliable based on the site-specific circumstances involved. Generally, alternatives relying solely on long-term management controls such as caps, liners, and leachate collection systems to provide protection have the lowest long-term effectiveness and permanence; however, this may be appropriate where low-concentration material is to be contained or where excavation is not practicable. Many alternatives will involve combinations of treatment and containment and will consequently fall at various points along the permanence continuum depending on the volume and concentration of residuals remaining on site.

5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The anticipated performance of treatment technologies used in the alternatives is evaluated under this criterion. Alternatives that do not involve treatment achieve no reduction of toxicity, mobility, or volume through treatment and should not be described as doing so under this criterion (e.g., placing a cap over contaminated soil does not reduce mobility of PCBs through treatment). Alternatives that use treatment methods that have a high certainty of achieving substantial reductions (at least 90%) of PCBs have the greatest reduction of toxicity. Alternatives that treat the majority of the contaminated material through these processes achieve the greatest reduction in volume. Alternatives that utilize methods to encapsulate or chemically stabilize PCBs achieve reduction of mobility; however, most of these processes also increase the volume of contaminated material and this must be considered.

5.1.5 Short-Term Effectiveness

The effectiveness of alternatives in protecting human health and the environment during construction and implementation is assessed under short-term effectiveness. This criterion encompassess concerns about short-term impacts as well as the length of time required to implement the alternatives. Factors such as cross-media impacts, the need to transport contaminated material through populated areas, and potential disruption of ecosystems may be pertinent. Because PCBs do volatilize, remedies involving excavation will create short-term risks through the inhalation pathway. For actions involving large volumes of highly contaminated material this risk may be substantial; however, it can be controlled.

5.1.6 Implementability

The technical and administrative feasibility of alternatives as well as the availability of needed goods and services are evaluated to assess the alternative's implementability. Many of the treatment methods for PCBs require construction of the treatment system on-site since commercial systems for such techniques as KPEG and solvent washing may not be readily available. Other methods, such as bioremediation, require extensive study before their effectiveness can be fully assessed. This reduces the implementability of the alternative. Offsite treatment and disposal facilities must be permitted under TSCA and usually under RCRA as well if other contaminants are present. This may affect the implementability of alternatives that require PCB material be taken offsite due to treatment and disposal facility capacity problems and the need to transport contaminated material. Finally, the implementability of alternatives involving long-term management and limitations on site access to provide protection may be limited by the site location; e.g., flood plain, residential area.

5.1.7 Cost

Capital and operation and maintenance costs are evaluated for each alternative. These costs include design and construction costs, remedial action operating costs, other capital and short-term costs, costs associated with maintenance, and costs of performance evaluations, including monitoring. All costs are calculated on a present worth basis.

5.2 Selection of Remedy

The remedy selected for the site should provide the best balance of tradeoffs among alternatives with respect to the nine evaluation criteria. First, it should be confirmed that all alternatives provide adequate protection of human health and the environment and either attain or exceed all of their ARARs or provide grounds for invoking a CERCLA waiver of an ARAR. Some of the key tradeoffs for sites with

PCB contamination include:

- Alternatives that offer a high degree of long-term effectiveness and permanence and reduction of toxicity, mobility, or volume through treatment, such as incineration, generally involve high costs. Short-term effectiveness for such alternatives may be low since risks may increase during implementation due to the need to excavate and possibly transport contaminated material, resulting in cross-media impacts.
- Alternatives that utilize innovative methods, often less costly than incineration, to reduce toxicity, mobility, or volume are often more difficult to implement due to the need for treatability studies and to construct treatment facilities onsite. In addition, the treatment levels achievable and the long term effectiveness and permanence may be less certain.
- Alternatives that involve stabilization to reduce the mobility of PCBs and limit cross-media impacts that may result from incineration (particularly important when other contaminants such as volatile metals are present) at a lower cost than other treatment methods, have higher uncertainty over the long term but may provide advantages in long-term effectiveness over alternatives that simply contain the waste in place.
- Alternatives that simply contain PCBs do not utilize treatment to reduce toxicity, mobility, or volume of the waste, have lower long-term effectiveness and permanence than alternatives involving treatment, but are generally less costly, easy to implement, and pose minimal short-term impacts.

The relative trade-offs based on these considerations will vary depending on site specific considerations discussed in earlier sections; i.e., concentration and volume of PCBs, site location, and presence of other contaminants.

5.3 Documentation

Typically, a ROD for a PCB-contaminated site should include the following unique components in addition to the standard site characterization and FS summary information described in the Guidance on Preparing Superfund Decision Documents:

- Remediation goals defined in the FS. For the selected remedy, the ROD should describe:

  - Cleanup levels above which PCB-contaminated material will be excavated. A comparison of the levels selected to PCB Spill Policy levels and explanation of why they differ may be warranted.
  - Treatment levels to which the selected remedy will reduce PCB concentrations prior to re-depositing residuals onsite or in a landfill. The consistency of these levels with the TSCA requirements (i.e., the requirement to demonstrate achievement of 2 ppm or less in solid treatment residue for material that will remain on site with no controls), and RCRA LDR requirements for hazardous wastes, should be noted.

- A description of technical aspects of the remedy, such as the following (should be included in alternative descriptions):
  - Treatment process, including the disposition of all effluent streams and residuals.
  - Time frame for completing the remedy and controls that will be implemented during this time to ensure protection of human health and the environment.
  - Long term management actions or site controls that will be implemented to contain or limit access to PCBs remaining on site. The consistency with RCRA closure and TSCA chemical waste landfill measures, and necessary TSCA waivers, should be indicated.

Chapter 6

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APPENDIX A

SUMMARY REPORT

FY82 - FY89 RECORDS OF DECISION ADDRESSING PCB-CONTAMINATED MEDIA

SUMMARY REPORT OF FY82 THROUGH FY89
RECORDS OF DECISION WHICH ADDRESS POLYCHLORINATED BIPHENYLS
AS A CONTAMINANT OF CONCERN

SITE-NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
REGION 01							
Cannon Engineering/Plymouth, MA [03/31/88] [F] Decontamination of all structures and debris with offsite disposal; excavation of contaminated soils with onsite thermal aeration; excavation of PCB contaminated soils and offsite incineration and disposal; restrict ground water use; ground water monitoring.	$2,700,000 Capital Cost	RD: 89/4 RA: 91/4	Not Stated	Not Stated	Not Stated	Not Stated	Incineration selected.
Norwood PCBs, MA [09/29/89] [F] Excavation and onsite treatment of PCB-contaminated soils and sediments using solvent extraction; area specific soil target cleanup levels established based on area risk assessment exposure scenarios; offsite incineration of oil extract from solvent extraction process; soil cover over treated soils; decontamination of machinery using solvents; extraction and treatment of PCB-contaminated ground water using carbon adsorption with offsite disposal of spent carbon; ground water use controls; and wetlands restoration.	$16,100,000 Present Worth	RD: 91/3 RA: 92/4	1016 1254 1260	2,060 ppm sediment	1-25 ppm	31,550 cubic yards	Incineration was selected for oil extract from solvent extraction process. Incineration was chosen only as a contingency remedy for soil and sediment due to higher cost.
O'Connor, ME [09/27/87] [RP] Excavation and onsite treatment of approximately 23,500 cubic yards of soil and sediments containing PCBs	$13,590,000 Present Worth	RD: 91/4 RA: 94/1	1260	200,000 ppm max	Not Stated	23,500 cubic yards	Incineration was not selected as primary treatment due to its

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] . COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
using solvent extraction; solvent extract will be incinerated offsite; treated soils containing lead levels >248ppm will undergo solidification/stabilization treatment and offsite disposal; backfilling using clean and treated soils; pumping and offsite treatment of approximately 195,000 gallons of surface water containing PCBs; and extraction and onsite treatment of PCB (Arochlor 1260) contaminated ground water using filtration/carbon adsorption.							short-term air quality impacts on local community and onsite workers.
Ottati & Goss, NH [01/16/87] [S] Excavation of PCB contaminated soil and sediment and treatment using incineration following test burn; RCRA delisting evaluation to be conducted for ash residuals; aeration of other contaminated soils, including PCB soil with concentrations less than 20 ppm; pilot study to be conducted to demonstrate the aeration process.	$6,055,000 Present Worth	RD: 89/2, subsequent RD start pending trial RA: 91/4	Not Stated	143 ppm	1 ppm (sediment), 20 ppm (soil)	14,000 cubic yards	EPA feels that the recommended health-based excavation criterion of 20 ppm is appropriate for this site and is consistent with EPA draft guidance (Development of Advisory Levels for PCB Cleanup). Soil aeration will be consistent with RCRA requirements achieving 1 ppm for sediments with less than 20 ppm PCBs.
Pinette's Salvage Yard, ME [05/30/89] [F] Excavation and offsite incineration of PCB-contaminated soil with offsite disposal of ash; excavation and onsite solvent extraction of 5-50 ppm PCB	$3,420,000 Capital Cost	RD: 90/4 RA: 91/4	Not Stated	92 ppm	1 ppm	2,200 cubic yards	Incineration for PCB concentrations above 50 ppm. Solvent extraction for PCB concentrations

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
contaminated soil with collection of treatment waters in onsite storage tanks and treatment by carbon adsorption and disposal (unspecified) of carbon filters and water, offsite incineration and disposal of PCB oil by-products, and onsite backfilling of treated soils; consolidation of 500 cubic yards of 1-5 ppm PCB soil into excavated areas and cover with < 1 ppm PCB soil; extraction and onsite treatment of contaminated ground water using filtration and carbon adsorption with reinjection of treated water and disposal of carbon residuals (unspecified); offsite disposal of debris affecting remediation activities; O&M.							between 5 ppm and 50 ppm. Replace and cover for PCBs below 5 ppm.
Re-Solve, MA [07/01/83] [F] Excavation of oil leachate soils and four unlined lagoons with offsite disposal at a RCRA hazardous waste facility; capping, regrading, and revegetating of the six acre site.	$3,050,000 Capital Cost	RD: 83/4 RA: 87/4	Not Stated	Not Stated	Not Stated	3,900 cy (soil), 3,100 cy (lagoon)	Incineration was not considered as a remedial alternative in this Record of Decision.
Re-Solve, MA [09/24/87] [F] Dechlorination of PCB-contaminated soils using potassium polyethylene glycol (KPEG) with onsite disposal of treated soils.	$17,038,000 Present Worth	RD: 90/4 RA: 93/1	Not Stated	3,000 ppm	1 ppm (sediment), 25 ppm (soil)	22,500 cubic yards	Incineration not selected due to limited facilities (availability) and length of implementation time.
Rose Disposal Pit, MA [09/23/88] [RP] Excavation of soil and sediment with onsite incineration and disposal;	$6,450,000 Present Worth	RD: 90/3 RA: 91/3	Not Stated	Not Stated	13 ppm	15,000 cubic yards	Incineration selected.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
recovery of subsurface free product with offsite thermal destruction and disposal; extraction of ground water and treatment using air stripping and carbon adsorption with discharge to the aquifer.							
South Municipal Water Supply Well, NH [09/27/89] [F] Excavation and/or dredging of 1,170 cubic yards of wetlands sediments containing PCB levels >1ppm followed by offsite incineration and disposal of residuals; in-situ treatment of 7,500 cubic yards of soil contaminated by volatile organic compounds using carbon adsorption for air emissions; ground water treatment using air stripping; and ground water restrictions.	$3,394,519 Present Worth	RD: 91/3 RA: 92/4	Not Stated	Not Stated	1 ppm	1,170 cubic yards	Incineration selected.
Sullivan's Ledge, MA [06/29/89] [F] Excavation of contamianted soil and sediment with dewatering and onsite solidification and disposal; excavation, clearing, and onsite and offsite disposal of debris; capping of eleven of the twelve acre site; extraction and onsite treatment of contaminated ground water with onsite discharge of treated water to surface water or to a secondary treatment plant; diversion and lining of surface water; ground water institutional controls; O&M.	$10,000,000 Present Worth	RD: 91/1 RA: 92/4	Not Stated	2,400 ppm	10 ppm (soils), 1 ppm (sediment)	24,200 cy (soil), 1,900 cy (seds)	Selected remedy is cost-effective considering long-term effectiveness and the significant reduction of mobility equivalent to other treatment alternatives (i.e., incineration).

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Wells G&H, MA [09/14/89] [F] Excavation of PCB-contaminated soils with onsite incineration and backfilling of excavated areas; in-situ volatilization of 7,600 cubic yards of soils contaminated with volatile organic compounds using carbon adsorption for emissions; and extraction of ground water and treatment using air stripping and carbon adsorption.	$68,400,000 Present Worth	RD: 91/3 RA: 93/2	Not Stated	Not Stated	1.04 ppm	3,100 cubic yards	Incineration selected.
SUBTOTAL 11							
REGION 02							
Bridgeport Rental & Oil, NJ [12/31/84] [F] Excavation and onsite incineration of oily waste, sediment and sludge using a pyrotech mobile incinerator.	$35,050,000 Present Worth	RD: 88/2 RA: 92/4	Not Stated	>500 ppm	Not Stated	60,000 cubic yards	Incineration selected.
Burnt Fly Bog, NJ [11/16/83] [S] Excavation and offsite disposal of liquids, sludges, asphalt pines, drums, and contaminated soils from lagoons and wetlands; restoration of site contours and revegetation; ground water monitoring.	$7,310,000 Capital Cost	RD: 86/3 RA: 89/4	Not Stated	245 ppm	8.5 ppm	Not Stated	There are no mobile incinerators presently avaliable which can reliably incinerate PCB waste. In addition, the process would generate ash residual, wastewater, and air emmissions which would require treatment or secure disposal.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Burnt Fly Bog, NJ [09/29/88] [S] Excavation of contaminated materials and offsite disposal; containment of contaminated soil in westerly wetlands; construction of a security fence and access road; treatability studies will determine the most appropriate remedy for the westerly wetlands.	$6,100,000 Present Worth	RD: 90/2 RA: 91/2	Not Stated	??	5 ppm (soils)	62,000 cy (soil) 1,400 cy (seds)	Contamination found in the downstream area, while significant enough to pose a threat in the stream, is at sufficiently low concentration that treatment is not warranted. At this low concentration, EPA feels that containment in a RCRA or TSCA permitted facility would be protective.
Chemical Control, NJ [09/23/87] [F] In-situ fixation of contaminated soil (drill large diameter soil borings, inject chemical fixating material and mix with soil); treatability studies will be conducted during remedial design.	$7,280,000 Capital Cost	RD: 91/2 RA: 93/1	1242 1254 1260	6 ppm	Not Stated	18,000 cubic yards	Incineration is more expensive than the selected alternative and does little to further reduce risk at the site.
Clothier Disposal, NY [12/28/88] [S] Cover contaminated soil containing less than 1 ppm PCBs with one foot of clean soil; installation of rip rap to prevent soil erosion; long-term ground water, surface water, air and sediment monitoring; institutional controls including land use and deed restrictions.	$500,000 Present Worth	RD: 89/3 RA: 90/4	1242	2.7 ppm	1 ppm	2,500 cubic yards	EPA determined that the risk levels associated with the residual contamination was minimal and within the range considered acceptable for Superfund remedies. The selected remedy provides additional protection by reducing the threat of contact and ingestion through capping.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
GE Moreau, NY [07/13/87] [RP] Excavation of 8,600 cubic yards of soil with onsite disposal within existing slurry wall containment area; cap disposal area; extention of public water supply to approximately 100 homes; institutional controls.	$4,664,000 Capital Cost	RD: 87/4 RA: 89/3	Not Stated	3,000 ppm	Not Stated	8,600 cubic yards	Incineration onsite or offsite for some 8,600 cubic yards of material would be prohibitively expensive compared to the other two remedial alternatives described. Incineration was therefore eliminated from future consideration.
Hooker/Hyde Park, NY [11/26/85] [FE] Extraction and onsite phase separation of non-aqueous phase liquids (NAPL) from ground water followed by thermal destruction.	$17,000,000 Total Cost	RD: 86/4 RA: 92/1	1248	3,000 ppm	Not Stated	Not Stated	Incineration selected.
Hudson River PCB, NY [09/25/84] [F] In-situ containment of remnant shoreline deposits; covering of affected areas with soil, regrading, and seeding; stabilization of river bank, if necessary.	$2,950,000 Capital Cost	RD: 89/4 RA: 92/1	Not Stated	1,000 ppm	Not Applicable	Not Applicable	The capital costs associated with constructing a multi-incinerator system that would have the capacity to handle the massive amounts of PCB sediment (at the site) would approach 250 million dollars.
Kin-Buc Landfill, NJ [09/30/88] [RP] Extraction of ground water and aqueous phase leachate and onsite treatment using carbon adsorption and aerobic/anaerobic biodegradation treatment with onsite residual	$16,635,000 Present Worth	RD: 90/2 RA: 93/1	Not Stated	5,822 ppm	Not Stated	3,000,000 gallons (leachate)	It would be difficult for a single incinerator facility to dedicate itself to handling such a large volume of hazardous

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
discharge to surface water; collection and offsite incineration of oily phase leachate; installation of a slurry wall and cap with periodic monitoring; O&M.							waste. Even if an incinerator dedicated itself to disposing Kin-Buc wastes, it is estimated that it would take 35 years to complete incineration.
Krysowaty Farm, NJ [06/20/84] [F] Excavation and offsite disposal of contaminated soils and wastes at an approved PCB facility; monitoring of onsite wells; provide alternate water supply to affected residents; post-closure environmental monitoring.	$2,164,014 Capital Cost	RD: 85/4 RA: 86/2	1221 1260	300 ppm	Not Stated	4,000 cubic yards	PCB contamination at the site did not exceed 500 ppm; therefore, disposal of contaminated soils will occur in a TSCA approved landfill. If soils are encountered with PCB levels above 500 ppm, these soils will be incinerated per TSCA requirements.
Ludlow Sand & Gravel, NY [09/30/88] [FE] Excavation of contaminated soil and sediment and onsite consolidation, disposal, and capping; collection of leachate using either a passive drain system or an active extraction well system and dewatering of contaminated leachate and ground water with onsite discharge of effluent to surface water or offsite discharge; multimedia monitoring.	$3,727,000- $14,548,900 Present Worth	RD: 91/1 RA: 93/2	Not Stated	482 ppm	10 ppm	10,000 cubic yards	Thermal treatment (incineration) was not expected to offer significant increases in protectiveness to public health and the environment, or short- or long-term effectiveness for the increased cost.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Renora, NJ [09/29/87] [FE] Excavation and offsite landfilling of PCB-contaminated soils; excavation and onsite biodegradation of PAH-contaminated soils; backfilling; grading; and revegetation.	$1,344,000 Capital Cost	RD: 88/4 RA: 90/4	1260	37,000 ppm	5 ppm	1,100 cubic yards	Excavation and offsite disposal also may include offsite incineration as a component of the selected remedy.
Swope Oil & Chemical, NJ [09/27/85] [F] Excavation and offsite incineration of PCB "hot spots"; removal of tanks, buildings, and debris with offsite incineration; extraction and offsite incineration of aqueous tank contents; offsite disposal of non-aqueous tank contents; excavation of PCB contaminated soil and buried sludge area with offsite disposal.	$3,134,683 Total Cost	RD: 88/4 RA: 90/4	1242 1248 1254 1260	500 ppm	5 ppm	145 cy > 50 ppm 8,650 cy < 50 ppm	Total site contamination not incinerated due to cost.
Wide Beach Development, NY [09/30/85] [S] Conduct pilot study on KPEG (potassium polyethylene glycol) treatment to determine effectiveness in neutralizing the PCB contaminated soil.	$9,295,000 Present Worth	RD: 89/2 RA: 91/1	1254	1,026 ppm	10 ppm	22,300 cubic yards	Incineration not retained as a viable alternative through preliminary screening. No rationale was provided in the ROD.
York Oil, NY [02/09/88]. [F] Excavation and dewatering of PCB contaminated soil and sediments with solidification in a mobile onsite unit, the stabilized material will be tested to verify its non-leachability and then disposed onsite; extraction of ground water with onsite treatment using an oil skimmer and oil/water separator with discharge into a modular water treatment unit; offsite treatment (to	$6,500,000 Capital Cost	RD: 91/1 RA: 93/2	1248 1254 1260	210 ppm	10 ppm (soil) 1 ppb (ground water)	30,000 cubic yards 25,000 gallons	Incineration was not selected because further treatment of the residual ash following thermal destruction may be needed to fuse the high concentration of metals found onsite into the residual ash in a non-hazardous form.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
be selected following treatability studies) of PCB-contaminated tank oils; demolition and decontamination of the empty storage tanks.							
SUBTOTAL 15							
REGION 03							
Delaware Sand & Gravel, DE [04/22/88]	[FE]						
Excavation of PCB-contaminated soil at Drum Disposal Area and Ridge Area; temporary onsite storage followed by onsite mobile incineration of excavated soil and waste; treatability studies; residual ash will be analyzed and disposed onsite.	$18,250,000 Total Cost	RD: 90/2 RA: 93/4	Not Stated	49 ppm	Not Stated	29,722 cubic yards	Incineration selected.
Douglassville Disposal, PA [06/24/88]	[S]						
Removal, transportation, and offsite incineration of liquid and sludge tank waste; decontamination of tanks, piping, processing equipment, and building materials designated for salvage or reuse to a level not to exceed 100 ug/100 square centimeters PCBs on the surface; offsite disposal of building rubble, concrete, asphalt, and other materials that cannot be decontaminated to less than 50 ppm PCBs and treatment (dewatering or incineration) of generated decontamination fluids.	$4,050,000 Capital Cost	RD: 89/3 RA: 91/1	1260	6,400 ppm	Not Stated	200,000 gallons	Incineration selected.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Douglassville Disposal, PA [06/30/89] [S] Excavation and onsite thermal treatment of contaminated soils, sludges and sediments with solidification and onsite disposal of ash residuals; installation of soil covers in contaminated source areas; deed restrictions.	$39,280,670- $53,619,000 Capital Cost	RD: 90/3 RA: 91/4	Not Stated	1,889 ppm	Not Stated	48,400 cubic yards	Incineration selected.
Fike Chemical, WV [09/29/88] [F] Excavation and removal of tanks and drums with offsite incineration and disposal; drainage and onsite treatment of lagoon sludge using ion exchange or chemical oxydation; wastewater treatment using granulated activated carbon with offsite residual discharge to surface water.	$13,130,000 Present Worth	RD: 89/2 RA: 90/1	Not Stated	Not Stated	Not Stated	Not Stated	Incineration selected.
Lehigh Electric, PA [02/11/83] [F] Excavation and offsite disposal of soils greater than 50 ppm; additional removal of soil where cost-effective; demolition of buildings onsite; grading and revegetation; O&M.	$6,401,000 Capital Cost	RD: 84/1 RA: 84/4	Not Stated	110,000 ppm	50 ppm	18,800 cubic yards	There are no mobile incinerators permitted to operate in Pennsylvania. Operating costs also would be excessive, making this option not cost-effective.
M.W. Manufacturing PA [03/31/89] [F] Excavation of contaminated waste and soil followed by offsite incineration at a RCRA permitted facility; incinerator ash will be disposed offsite at a RCRA landfill.	$2,061,000 Capital Cost	RD: 89/4 RA: 90/1	Not Stated	54 ppm	Not Stated	875 cubic yards	Incineration selected.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLOR	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Ordinance Works Disposal, WV [03/31/88] [FE]							
Onsite mobile incineration and containment of excavated soils and sediments; onsite disposal of non-EP toxic ash residuals in an inactive landfill; offsite disposal of EP toxic ash at an approved RCRA facility; close inactive landfill using multi-layer cap.	$6,718,000 Present Worth	RD: 91/2 RA: 93/4	1016 1260	229 ppm	5 ppm	Not Stated	Incineration selected.
SUBTOTAL 7							
REGION 04							
Airco Carbide, KY [06/24/88] [RP]							
Excavation and consolidation of contaminated sediments and surface soils in former Burn Pit Area and cap; extraction of ground water and onsite treatment using air stripping, carbon adsorption, and oil/water seperation with discharge of treated water offsite to surface water; deed restrictions; construction of organic vapor recovery system; construction of flood plain protection dike; installation of a leachate extraction system and upgrade existing clay cap.	$6,090,000 Present Worth	RD: 89/3 RA: 91/4	Not Stated	4 ppm (seds)	Not Stated	5,000 cubic yards	Incineration was not retained as a viable alternative through preliminary screening. No rationale was provided in the ROD.
Geiger/C&M Oil, SC [06/01/87] [F]							
Excavation and onsite thermal treatment of soil to remove organics followed by solidification/stabilization of thermally treated soil following treatability studies.	$7,700,000 Present Worth	RD: 89/2 RA: 91/4	1254	4 ppm	1 ppm	11,300 cubic yards	Incineration selected.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Goodrich, B.F. Chemical Group, KY [06/24/88] [RP] Extraction of ground water and treatment using air stripping, carbon adsorption, and oil/water separation with discharge of treated water to surface water; deed restrictions; excavation and placement of the contaminated surface soils in former burn pit area and cap; construction of an organic vapor recovery system; construction of a flood protection dike; installation of a leachate extraction system and upgrade existing landfill clay cap.	$6,090,000 Present Worth	RD: 89/3 RA: 91/4	Not Stated	4 ppm (seds)	Not Stated	5,000 cubic yards	Incineration not retained as a viable alternative through preliminary screening. No rationale was provided in the ROD.
Mowbray Engineering, AL [09/25/86] [F] Excavation of contaminated soils and either on- or offsite incineration or onsite stabilization/solidification of these soils.	$750,000 Capital Cost	RD: No RD date; removal action will be conducted to implement ROD; solidification was chosen as the selected action; RA: 87/4	1260	1,500 ppm	25 ppm	4,800 cubic yards	Incineration preferred in ROD, however, Regional Coordinator stated that solidification was selected by the removal program.
Newport Dump, KY [03/27/88] [FE] Restoration and extention of leachate collection system; resoration, regrading, and revegetation of clay cap; monitoring of ground water and soil; O&M.	$516,000 Capital Cost	RD: 88/1 RA: 88/1	1242 1260	1,020 ppm	Not Applicable	Not Applicable	Incineration was not considered as a remedial alternative in this Record of Decision.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Newsom Brothers Old Reichold, MS [09/18/89] [F]							
Excavation of PCB-contaminated sediments and soils with offsite disposal; excavation of non-PCB contaminated black tar-like waste material with offsite treatment using incineration and offsite disposal of ash at a RCRA landfill	$14,180,249 Present Worth	RD: 90/4 RA: 92/2	1254	10 ppm sediment	0.12 ppm	48,370 cubic yards	Incineration for soils and sediments was not selected due to uncertainty over volume of material to be treated and lack of acceptance by State and community. Higher cost was considered a minor influence in decision.
Pepper's Steel & Alloy, FL [03/12/86] [FE]							
Solidification of PCB contaminated soils with a cement type mixture and onsite placement of residuals; residual analysis of solidified soils prior to disposal.	$5,212,000 Present Worth	RD: 87/1 RA: 89/3	Not Stated	2,700 ppm	1 ppm	48,000 cubic yards	Incineration was not selected due to serious environmental disadvantages (2-16% of lead escapes into the aquifer), inavailability of incinerators, complexity of waste matrix, time intensive remedy, costly, and requires additional waste handling.
Smith's Farm Brooks, KY [09/29/89] [F]							
Excavation of PCB contaminated soil, waste material and sediments from site Area B with onsite incineration followed by solidification/fixation of treatment residuals; capping of soils in Area A; construction of leachate collection system; access restrictions; and ground water monitoring.	$26,900,000 Present Worth	RD: 91/1 RA: 93/3	1248 1254 1260	6,100-13,100ppm	2 ppm	26,200 cubic yards	Incineration selected.

SUBTOTAL 8

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
REGION 05							
A&F Materials/Greenup, IL [06/14/85] [FE]							
Excavation and offsite disposal of soil contaminated above recommended action levels; decontamination and removal of onsite equipment and buildings; ground water monitoring; O&M.	$824,000 Capital Cost	RD: 84/3 RA: 85/4	Not Stated	Not Stated	1 ppm	1,332 cubic yards	Incineration was not considered as a remedial alternative in this Record of Decision.
Alsco Anaconda, OH [09/08/89] [RP]							
Excavation of 50 cubic yards of sludge with PCB levels >500ppm followed by offsite incineration and disposal; excavation of remaining 3,250 cubic yards of sludge and soils (PCB cuncentrations <500ppm) with offsite disposal in compliance with all RCRA and TSCA regulations; backfilling excavated areas; and deed restrictions.	$4,161,066 Capital Cost	RD: 91/3 RA: 93/4	Not Stated	3,000 ppm max sludge	Not Stated	3,300 cubic yards	Incineration selected for PCB concentrations >500ppm.
Belvidere Municipal Landfill #1, IL [06/30/88] [S]							
Soils in the drum disposal area will be resampled and those containing greater than 50 ppm PCBs will either be excavated and incinerated offsite or left in place and capped with a soil cover; soils contaminated with less than 50 ppm PCBs will be consolidated with the landfill material prior to capping.	$5,617,000 Present Worth	RD: 90/1 RA: 92/3	1242 1254 1260	51,000 ppm	50 ppm	Not Stated	Incineration selected for soils containing greatrr than 50 ppm PCBs.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Bowers Landfill, OH [03/31/89] [RP] Capping; management of surface debris; erosion control and monitoring of ground water; O&M.	$4,267,500 Present Worth	RD: 90/4 RA: 92/1	1242 1248 1254	36 ppm	Not Stated	Not Stated	Incineration was not considered as an alternative remedy, and no rationale rationale was provided in the ROD.
Cross Brothers Pail, IL [09/28/89] [S] Resampling of localized PCB soil area to identify existence of PCB source; if identified the source area will be excavated and incinerated offsite at a TSCA incinerator; installation of a passive ground water collection and soil flushing system; ground water monitoring; and deed and access restrictions.	$2,076,500 Present Worth	RD: 91/2 RA: 92/4	1242 1248 1254 1260	42,900-112,000 pp	10 ppm	5 cubic yards	Incineration selected.
Fields Brook, OH [09/30/86] [F] Excavation of contaminated sediment with temporary storage, dewatering, test burns and onsite thermal treatment followed by onsite disposal of ash in a RCRA/TSCA landfill, unless determined to be non-hazardous.	$12,260,000 Capital Cost	RD: 91/3 RA: 94/1	Not Stated	518 ppm	50 ppm	16,000 cubic yards	Incineration selected.
Fort Wayne Reduction, IN [08/26/88] [F] Excavation of the western portion of the site for removal of 4,600 buried intact drums and incineration of the drum contents onsite or offsite; reconsolidation of excavated soils and wastes onsite followed by hybrid closure consisting of a compacted, continuous soil cover.	$10,020,000 Present Worth	RD: 91/3 RA: 91/4	Not Stated	14.2 ppm	10 ppm	230,000 gallons	Incineration selected for drum contents; incineration not selected for contaminated soil due to high costs.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
LaSalle Electrical Utilities, IL [09/29/86] [F] Excavation and incineration of contaminated soil and clean fill excavated areas; decontamination of onsite structures.	$26,400,000 Present Worth	RD: 87/4 RA: 90/1	1248 1254	5,800 ppm	5 ppm	25,530 cubic yards	Incineration selected.
LaSalle Electrical Utilities, IL [03/30/88] [F] Excavation and mobile onsite incineration of PCB contaminated soils and stream sediments with subsequent ash analysis to determine final disposal location; high pressure flushing and mechanical cleaning of sewer lines, and collection and treatment (to be detailed during design, but will include phase separation, filtration, and air stripping) of ground water containing PCBs at concentrations above 1 ppb.	$34,495,180 Present Worth	RD: 89/2 RA: 93/2	1248 1254	17,000 ppm	5 ppm (surface) 10 ppm (subsoils)	23,500 cubic yards	Incineration selected.
Laskin/Poplar Oil, OH [08/09/84] [F] Excavation and offsite incineration of PCB contaminated waste water and oils.	$1,043,000 Total Cost	RD: 86/2 RA: 92/4	Not Stated	500 ppm	Not Stated	250,000 gallons	Incineration selected.
Laskin/Poplar Oil, OH [09/30/87] [F] Excavation and incineration of oils, sludges and highly contaminated soils and offsite disposal of ash residuals.	$4,377,500 Present Worth	RD: 89/3 RA: 92/2	1221 1242 1254 1260	144 ppm	6 ppm	71,100 cubic yards	Incineration selected.
Laskin/Poplar Oil, OH [06/29/89] [S] Thermal destruction of contaminated soils, ash and debris with onsite disposal of ash if delisted or offsite disposal at a RCRA hazardous waste landfill; demolition and thermal	$11,000,000 Capital Cost	RD: 91/2 RA: 92/4	Not Stated	Not Stated	Not Stated	5,000 cubic yards	Incineration selected.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
destruction or decontamination of dioxin contaminated structures, if these structures cannot be decontaminated then contain in a concrete vault onsite and cap for temporary storage; drain retention and freshwater ponds with discharge to surface water and treatment as necessary; construct a multi-layer cap over soils exceeding performance levels; dewater site by natural ground water flow to surface water; ground and surface water monitoring and land use restrictions.							
Liquid Disposal, MI [09/30/87] [S] Excavation and onsite disposal of debris with solidification/fixation of soil and waste; extraction of ground water onsite and treatment using air strippers or ion exchange with discharge to surface water; construction of a slurry wall and cap.	$21,743,100 Capital Cost	RD: 90/2 RA: 92/4	Not Stated	Not Stated	Not Stated	136,650 cubic yards	The level of treatment afforded by incineration, while desirable, particularly for PCBs, is not cost-effective for the LDI site contaminants.
Miami County Incinerator, OH [06/30/89] [F] Excavation and consolidation of ash wastes and contaminated soils with disposal in north or south landfill and capping; vapor extraction and treatment of exhaust; extraction and treatment (unspecified) of ground water with discharge to POTW; pretreatment of ground water (unspecified) if necessary; alternate water supply.	$1,700,000-$3,500,000 Present Worth	RD: 92/1 RA: 92/2	Not Stated	Not Stated	Background Levels	22,000 cubic yards	Incineration would cost six to seven times as much as the selected remedy (vapor extraction) without providing a proportionate benefit. Incineration would leave a residue which would need to be disposed onsite or at an appropriate landfill offsite.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Midco I, IN [06/30/89] [RP] Excavation and onsite treatment of 12,400 cubic yards of contaminated soil and waste and 1,200 cubic yards of contaminated sediments by a combination of vapor extraction and solidification/stabilization followed by onsite disposal; installation and operation of a ground water pumping system to intercept contaminated ground water followed by reinjection into a deep well; installation of RCRA cap.	$9,094,000 Capital Cost	RD: 91/1 RA: 93/1	1242 1254 1248	44 ppm	Not Stated	12,400 cy (soil) 1,200 cy (seds)	Incineration is more expensive than the selected alternative and does little to further reduce risk at the site.
Midco II, IN [06/30/89] [RP] Excavation and onsite treatment of 35,000 cubic yards of contaminated soil and waste, and 500 cubic yards of sediments by solidification/stabilization followed by onsite disposal of the solidified waste; installation and operation of a pumping system to intercept contaminated ground water followed by discharge to a deep injection well; installation of RCRA cap.	$11,755,400 Capital Cost	RD: 91/1 RA: 93/4	Not Stated	< 50 ppm	Not Stated	35,000 cy (soil) 500 cy (seds)	Incineration is more expensive than the selected alternative and does little to further reduce risk at the site.
Ninth Avenue Dump, IN [09/20/88] [F] Containment of the oil layer by constructing a soil-bentonite slurry wall extending into the clay layer 30 feet below the surface; extraction of oil and ground water within the containment area with treatment of ground water using oil/water separator and discharge into a ground water	$1,960,000 Capital Cost	RD: 90/3 RA: 92/1	1248 1254 1260	1,500 ppm	Not Stated	250,000-700,000 gallons	Incineration not selected because the oil layer is contaminated with chlorinated dibenzo-dioxins as well as PCBs and it may be difficult to find a commercial incinerator

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
recharge system; temporary onsite storage of contaminated oil in a secondary containment structure meeting RCRA and TSCA tank storage requirements.							willing to accept dioxin contaminated waste, and a mobile incinerator may not be cost-effective.
Ninth Avenue Dump, IN [06/30/89] [F] Excavation of oil contaminated waste, fill, debris, and sediments from on- and offsite surface water followed by onsite thermal destruction in a mobile incinerator; extraction, treatment (unspecified) and reinjection of contaminated ground water inside slurry wall to promote soil flushing; discharge of a small quantity of ground water outside slurry wall to compensate for infiltration; capping.	$22,209,000 Present Worth	RD: 91/3 RA: 93/4	Not Stated	Not Stated	Not Stated	36,000 cubic yards	Incineration selected.
Outboard Marine/Johnson, IL [05/15/84] [F] Dredge, dewater and fixate the four contaminated "hot spots" containing with PCB contaminated soil and sediments with offsite disposal. Total amount of PCBs is estimated to be 771,200 pounds.	$13,890,000 Capital Cost	RD: 85/3 RA: 91/4	Not Stated	155,000 ppm	50 ppm	222,400 cubic yards	Fund balancing used to waive applicable laws. Incineration not retained as a viable alternative through preliminary screening.
Outboard Marine/Johnson, MI [03/31/89] [F] **Amendment:** Construction of three containment cells to hold contaminated soil and sediment; excavation of PCB-contaminated sediment and soil with onsite thermal or chemical extraction, (or an effective alternative treatment) with offsite disposal of extracted PCBs; placement of treated sediment and	$19,000,000 Present Worth	RD: 90/2 RA: 91/4	Not Stated	710,000 ppm	> 500 ppm (sediment) > 10,000 ppm (Soil)	Not Stated	There are no PCB extraction or soil treatment technologies specified in this ROD. There is no rationale documented in the ROD concerning which treatment technology will be selected.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
soil in lined and capped containment cells; treatment of dredge water by sand filtration and carbon adsorption with discharge to either an offsite sanitary sewer or onsite.							
Rose Township Dump, MI [09/30/87] [S] Excavation of contaminated soil with onsite incineration and onsite or offsite residual ash disposal; extraction and treatment of contaminated ground water using chemical coagulation, air stripping, and activated carbon adsorption with onsite discharge of treated water; O&M.	$32,547,000 Capital Cost	RD: 90/3 RA: 92/3	Not Stated	980 ppm	10 ppm	50,000 cubic yards	Incineration selected.
Schmalz Dump, WI [08/13/85] [F] Excavation and offsite disposal or offsite incineration and offsite residual ash disposal of contaminated building debris.	$2,088,300 Capital Cost	RD: 87/4 RA: 89/1	Not Stated	3,100 ppm	Not Stated	3,500 cubic yards	Incineration is an option for PCB-contaminated debris removed from the site.
Summit National Liquid Disposal, OH [06/30/88] [F] Excavation and onsite mobile incineration of PCB contaminated soil, sediment, and debris, including tank contents with disposal of incinerated residual in an onsite RCRA landfill; pre-burn tests will be required to demonstrate the type of thermal destruction to be employed at the site.	$25,000,000 Present Worth	RD: 90/2 RA: 95/3	Not Stated	Not Stated	Not Stated	32,000 cubic yards 88,000 gallons	Incineration selected.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Wedzeb, IN [06/30/89] [F] Flushing and decontamination of sewer lines; filtration of sewer water to remove PCB contaminated sediments; monitoring of the water and refiltering, if necessary with discharge to a POTW; analyze two barrels of sediment and 20 barrels of RI generated waste; > 50 ppm PCB levels will be treated by offsite incineration and levels < 50 ppm PCB will be disposed offsite at a EPA approved site.	$24,500 Present Worth	RD: 91/2 RA: 93/3	Not Stated	370 ppm (seds)	10 ppm	Not Stated	Incineration for PCB concentrations above 50 ppm, offsite TSCA land disposal for concentrations below 50 ppm.
SUBTOTAL 24							
REGION 06							
French Limited, TX [03/24/88] [F] In-situ biodegradation of sludges and contaminated soils using indigenous bacteria with aeration of the lagoon waste to enhance the degradation process; residues from the treatment process will be stabilized and disposed onsite.	$47,000,000 Present Worth	RD: 90/1 RA: 95/2	Not Stated	616 ppm	23 ppm	149,000 cubic yards	Incineration is more expensive than the selected alternative and does little to further reduce risk at the site.
Geneva Industries, TX [09/18/86] [S] Offsite disposal of surface structures to hazardous waste landfill; excavation of soils with > 100 ppm PCBs and drums with offsite disposal to an EPA-approved facility; construction of a multi-layer clay cap and slurry wall; extraction and treatment of ground	$14,992,000 Capital Cost	RD: 88/1 RA: 91/3	Not Stated	1,750 ppm	100 ppm	22,500 cubic yards	The selected remedy offers the same level of protection for public health and the environment. Since onsite incineration was found to generally cost more than

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
water using carbon adsorption with discharge to adjacent flood control channel.							offsite remedies, offsite disposal has been selected as the remedy for this site.
Gurley Pit, AR [10/06/86] [FE] Construction of an onsite pond water treatment unit with discharge to Bayou; removal of contaminated solids from pond water and dispose with pit sludge; removal of oil from pond water using oil/water separator with treatment using PCB-approved incinerator; extraction and stabilization of pit sludge with pond solids with onsite disposal; excavation of soil and sediments with onsite disposal with stabilized material; cap stabilized wastes; O&M.	$5,780,000 Capital Cost	RD: 88/4 RA: 91/2	Not Stated	20 ppm	Not Stated	17 cy (oil), 15,984 cy (sludge)	The large increase in cost for incineration for a small gain in containment weighted against incineration of sludge waste. In addition, a large quantity of waste would have to be transported to an incinerator. This would increase the danger of exposure of the public through accidental spills. Offsite incineration was selected for the small quantity of PCB-contaminated oil removed from the ponded water.
Hardage/Criner, OK [11/14/86] [FE] Extraction of surface and ground water with separation of NAPL followed by offsite incineration of organic liquids with offsite disposal of ash residuals, or onsite incineration with onsite disposal of solid ash residuals, and either recycle or treat (unspecified) residual liquids followed by offsite discharge; onsite treatment of soils	$68,000,000 Present Worth	RD: currently negotiating with PRP: 89/1; RA: assuming RP judgment 92/4	1260	> 50 ppm	Not Stated	175,000 cubic yards	Determine soil treatment remedy during remedial design.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
and debris by one or more of the following: chemical neutralization, solidification, dewatering, chemical oxidation/reduction, air stripping; rotory-kiln incineration bench-scale test to be conducted for moisture content and reactions of soil/fluid combinations and if successful, conduct pilot study and emissions testing.							
MOTCO, TX [03/15/85] [F]							
Excavation and offsite incineration of PCB liquid organics at a permitted TSCA facility; excavation and offsite disposal of PCB-contaminated tars and sludges at a RCRA landfill; extraction of pit water and treatment at an industrial waste water treatment plant.	$42,300,000 Capital Cost	RD: 86/4 RA: 94/1	Not Stated	100 ppm	Not Stated	18,000 cubic yards	Incineration selected.
Sheridan Disposal Services, TX [12/29/88] [RP]							
Excavation and onsite biotreatment of all sludges, debris, floating oil and emulsion, and soils containing > 25 ppm of PCBs; residuals, reduced to < 50 ppm PCBs, will be stabilized onsite, returned to the pond and capped; if the residuals are > 50 ppm PCBs, the pond will be a RCRA compliant landfill; decontamination and disposal of all onsite tanks and processing equipment with onsite treatment (unspecified) or offsite disposal depending on contents; treatment of storm and waste water streams to remove solids, metal and organics with discharge to surface water; institutional controls.	$28,346,000 Capital Cost	RD: 91/1 RA: Not Available	Not Stated	223 ppm	25 ppm	44,000 cubic yards	Bioremediation significantly reduces mobility, toxicity and volume and essentially eliminates the source of contamination to the ground water. Incineration is mechanically complex, using highly specialized costly equipment and operators and would have required approved offsite disposal of ash.

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Sol Lynn/Industrial Transformers, TX [03/25/88] [F]							
Excavation and treatment of contaminated soil with an alkali metal polyethylene glycolate (APEG) reagent in a batch reactor; pretreatment, if necessary, and discharge of liquid by-products of treatment to a POTW; APEG feasibility testing will be conducted during the design phase.	$2,200,000 Present Worth	RD: 90/4 RA: 93/2	Not Stated	350 ppm	25 ppm	2,400 cubic yards	Incineration not selected because it is not cost-effective and no additional protection would be provided by this treatment.
SUBTOTAL 7							
REGION 07							
Doepke Disposal Holliday, KS [09/21/89] [RP]							
Removal and offsite treatment of contaminated liquids ponded under former surface impoundments; construction of an impermeable multi-layer cap over majority of waste area, including soils contaminated with PCBs; deed and access restrictions; and ground water monitoring.	$5,970,000 Present Worth	RD: 91/1 RA: 93/3	1248 1254 1260	.07-.393 ppm	Not Stated	Not Stated	Due to the magnitude of waste and low PCB concentrations further studies will be performed to fully characterize soils. Incineration not considered as alternative for this operable unit.
SUBTOTAL 1							
REGION 09							
Lorentz Barrel & Drum, CA [09/28/88] [FE]							
Extraction of PCB contaminated ground water and onsite treatment using a packaged ozone-UV system with discharge of treated effluent onsite to a storm sewer.	$3,238,000 Present Worth	RD: 90/1 RA: 91/4	1221 1242 1254 1260	6.4 ppm	0.065 ppb	Not Stated	Incineration was not discussed as a treatment alternative in the ROD.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
MGM Brakes, CA [09/29/88] [FE] Excavation of PCB-contaminated soil with offsite disposal of soil; extraction and treatment of wastewater from dewatering process in a mobile treatment system (unspecified) and discharge of treated water either onsite or to a POTW; soil containing > 50 ppm PCBs will be transported to a Class I TSCA-permitted disposal facility; soil containing 10-50 ppm PCBs will be transported to a Class II CA DOHS-permitted facility; demolition of processing building, crushing of the concrete slab and excavation of the underlying soil contaminated with > 10 ppm PCBs followed by transportation and offsite disposal of the contaminated concrete in an appropriate disposal facility.	$5,369,300 Present Worth	RD: 90/4 RA: 91/4	Not Stated	4,500 ppm	10 ppm	13,510 cubic yards	Incineration was not selected because of community opposition and limited availability of incinerators.
SUBTOTAL 2							
REGION 10							
Commencement Bay-Near Shore/Tide Flats, WA [09/30/89] [RP] Source remediation involving control of effluent sources; PCB-contaminated sediment remediation includes natural attenuation and utilization, as appropriate, of four alternatives including in-situ capping, confined aquatic disposal, confined nearshore	$32,300,000 Total Cost	RD: 93/4 RA: 94/4	Not Stated	Not Stated	1,500 ppm sediment	1,181,000 cubic yards	Most problem areas are characterized by significant metals contamination, which is not mitigated by incineration. Additionally, marine

(CONTINUED)

SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
disposal, and removal and upland disposal onshore; site use restrictions; and sediment monitoring.							sediments were found to have very low BTU content, making incineration extremely energy intensive and less cost effective considering the volume of contaminated material.
Commencement Bay/NTF, WA [12/30/87] [FE] Excavation and stabilization of PCB contaminated soils; extraction and stabilization of ponded water and sediments with onsite disposal of treatment residuals and asphalt capping of the entire stabilized matrix	$3,400,000 Present Worth	RD: 91/1 RA: 92/1	Not Stated	204 ppm	1 ppm (soil) 2 ppb (ponded water)	45,000 cubic yards	Incineration not selected as a viable alternative through a preliminary feasibilty study due to high cost.
Northwest Transformer, WA [09/15/89] [F] Excavation, consolidation and treatment of soils with PCB concentrations > 10 ppm using in-situ vitrification; well abandonment; construction of soil cover; and ground water monitoring.	$771,000 Total Cost	RD: 91/4 RA: 93/2	1260	1-10 ppm	10 ppm	1,200 cubic yards	The thermal destruction ion process best for this site was determined to be vitrification based on ease of mobilization, lower cost, lack of residuals, and local acceptance of treatment process.
Pacific Hide & Fur Recycling, ID [06/28/88] [RP] Excavation of contaminated soil with solidification of soils; installation of soil cover over solidified soils with either on- or offsite disposal; onsite containment of contaminated soils if solidification found to be not viable through a pilot study; decontamination of debris with either on- or offsite disposal.	$1,890,000 Present Worth	RD: 89/4 RA: 91/4	Not Stated	Not Stated	25 ppm (restricted) 10 ppm (non-restricted)	8,200 cubic yards	Incineration not selected as a viable alternative through preliminary screening due to difficulty of implementation.

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SITE NAME, STATE [ROD SIGN DATE] [LEAD] COMPONENTS OF THE SELECTED REMEDY	COSTS	RD/RA COMPLETE	AROCHLORS	PRE-TREATMENT CONCENTRATION	EXCAVATION LEVELS	ESTIMATED VOLUME	RATIONALE WHY INCINERATION WAS NOT SELECTED
Queen City Farms, WA [10/24/85] [FE] Phase separation of sludge with solidification and liquid stabilization. Offsite disposal of contaminated soil.	$3,439,000 Total Cost	RD: 87/1 RA: 87/1	1260	125 ppm	Not Stated	5,200 cubic yards	Incineration not selected due to cost, limited incinerator capacity and difficulty in transportation.
Western Processing/Phase II, WA [09/25/85] [F] Conduct bench-scale tests using in-situ solidification/stabilization; if successful, conduct pilot studies.	$18,100,000 Present Worth	RD: 88/4 RA: 89/2	Not Stated	1,128 ppm	2 ppm, (Offsite) 50 ppm (Onsite)	10,650 cubic yards	Incineration not retained as a viable alternative through preliminary screening.

SUBTOTAL 6

TOTAL 81

APPENDIX B

DIRECT CONTACT RISK CALCULATION

Risk Calculations for an Individual Contacting PCB Contaminated Soil

Risk are calculated below for an individual in contact with PCB contaminated soil at three concentrations, 0.1 ppm, 1 ppm, and 10 ppm. The pathways considered are soil ingestion, dermal contact and inhalation of volatilized PCBs.

Soil Ingestion Scenario

Some of the PCB in the soil is going to volatilize throughout the years. Therefore, if a more in-depth assessment is required, the volatilization of PCB needs to be accounted for. The equations used to account for the volatilization of PCBs from the soil over certain period of time are derived in Appendix A of the EPA document titled Development of Advisory Levels for Polychlorinated Biphenyls (PCBs) Cleanup (U.S. EPA, 1986a).

Assumptions

Exposure Factor	**Value**	**Reference or Comment**
Child Ingestion rate (mg/day)	200	U.S. EPA, 1989f
Adult Ingestion rate (mg/day)	100	U.S. EPA, 1989f
Exposure Duration for a child (yrs)	6	U.S. EPA, 1989f
Exposure Duration for an aduld (yrs)	24	(30 - 6)
Exposure Frequency (days/yr)	365	U.S. EPA, 1989f
Body weight child (kg)	16	U.S. EPA, 1989f
Body weight adult (kg)	70	U.S. EPA, 1989f
Absorption fraction	30%	U.S. EPA 1986a

$$\text{Exposure} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

where,
C = concentration of PCB in soil

IR = intake rate

ED = exposure duration

EF = exposure frequency

BW = body weight

AT = averaging time (70 yrs for a carcinogen)

To estimate exposure, the average concentration of PCBs in soil over the exposure period is calculated. The concentration of PCBs will decrease with time due to volatilization. This concentration is estimated using the equation A-35 from the 1986 PCB cleanup guidance for an uncovered surface.

$$C_s = C_{so} \frac{1}{z} \quad \text{erf} \, \frac{z}{2 \quad t} \, dz$$

where,

C_s = average concentration of PCB in soil (ppm)

C_{so} = initial concentration of PCB in soil (ppm)

z = depth of contamination (cm)

= constant defined by $\dfrac{D_{ei} \times E}{[E + P_s \times (1 - E) \times K_d/H]}$

t = exposure time divided by 4 (sec)

D_{ei} = effective diffusivity (cm^2/s) = $D_i \times E^{1/3}$

D_i = molecular diffusivity (cm^2/s)

E = pore porosity (unitless)

P_s = bulk density of soil (g/cm^3)

K_d = soil/water partition coefficient (mg/g soil)/(mg/cm^3 water)

H = Henry's Law Constant ($atm\text{-}m^3/gmol$)

Example calculation for the following set of assumptions:

C_{so} = 1 ppm

z = 25.4 cm (10 inches)

D_i = 0.05 cm^2/s

E = 0.35

P_s = 2.65 g/cm^3

K_d = 1000 $(\text{mg/g soil})/(\text{mg/cm}^3 \text{ water})$

H = 8.37×10^{-3} $(\text{atm-m}^3/\text{gmol})$

t = 6 yrs/4 = 1.89×10^8 sec/4 = 4.73×10^7 sec

$$C_s = \frac{1}{25.4} \quad \text{erf} \frac{z}{21.53} \quad dz$$

This equation is solved by assuming different values of z and evaluating the error function using the table attached. Then the integral is evaluated numerically using the Trapezoidal Rule.

z (cm)	erf(x)
0	0
5	0.2550
10	0.4847
15	0.6778
20	0.8116
25	0.9103

Using the Trapezoidal Rule:

$$f(x)\,dx = \frac{b-a}{2n}\left[f(x_0) + 2\,f(x_1) + 2\,f(x_2) + \ldots 2\,f(x_{n-1}) + f(x_n)\right]$$

$$C_s = \frac{(25.4-0)}{(25.4)(2)(5)}\left[0 + 2(.02550) + 2(0.4847) + 2(0.6778) + 2(0.8116) + 0.9103\right]$$

C_s = 0.54 ppm

The same procedure is used to determine the average concentration for a period of 30 yrs which yields a concentration of 0.28 ppm for the adult exposure.

Example calculation for soil ingestion by a child at an initial concentration of 1.0 ppm

$$\text{Exposure} = \frac{0.54\text{ mg}}{\text{kg}} \times \frac{200\text{ mg}}{\text{day}} \times \frac{365\text{ days}}{\text{yr}} \times 6\text{ yrs} \times \frac{1}{16\text{ kg}} \times \frac{1}{70\text{ yrs}}$$

$$\times \frac{\text{yr}}{365\text{ days}} \times \frac{10^{-6}\text{ kg}}{\text{mg}}$$

$$= 5.8 \times 10^{-7}\text{ mg/kg-day}$$

Similarly, the adult exposure is estimated.

$$\text{Exposure} = \frac{0.28\text{ mg}}{\text{kg}} \times \frac{100\text{ mg}}{\text{day}} \times \frac{365\text{ days}}{\text{yr}} \times 24\text{ yrs} \times \frac{1}{70\text{ kg}} \times \frac{1}{70\text{ yrs}}$$

$$\times \frac{\text{yr}}{365\text{ days}} \times \frac{10^{-6}\text{ kg}}{\text{mg}}$$

$$= 1.4 \times 10^{-7}\text{ mg/kg-day}$$

The total exposure is calculated by adding the child and the adult exposure.

Total exposure = 7.2×10^{-7} mg/kg-day

Cancer risk is then calculated using a cancer potency factor for PCBs of 7.7 $(\text{mg/kg-day})^{-1}$ and multiplying by an absorption factor of 30%. The table below summarizes the total exposure and risk from soil ingestion (child + adult) for the three concentration values.

Soil Concentration (ppm)	**Total Exposure (mg/kg-day)**	**Risk**
0.1	7.2×10^{-8}	2×10^{-7} [B2]
1.0	7.2×10^{-7}	2×10^{-6} [B2]
10	7.2×10^{-6}	2×10^{-5} [B2]

Dermal Contact Scenario

As in the soil ingestion scenario, the concentration of PCB in the soil is needs to be averaged over the period of exposure to account for the volatilization of PCBs. Exposure is estimated for both a child and an adult. A child ages 3 - 18 years old wearing shorts and short sleeve shirt is assumed to be exposed 3 times/week during the spring and fall and 5 times/week during the summer months. The adult is assumed to be wearing long pants and short sleeve shirt while gardening 1 day/wk during spring, fall and summer.

Assumptions

Exposure Factor	Value	Reference
Surface area arms, hands and legs (average 3 -18 yrs) (m^2/event)	0.40	U.S. EPA, 1989f
Surface area arms and hands (adult) m^2	0.31	U.S. EPA, 1989f
Soil to skin adherence factor (mg/cm^2)	2.77	U.S. EPA, 1989f
Exposure frequency (child) (events/yr)	132	U.S. EPA, 1989f
Exposure frequency (adult) (events/yr)	52	judgement
Exposure duration (child) (yr)	15	(18 - 3)
Exposure duration (adult) (yr)	12	(30 - 18)
Body weight (child) (kg)	38	U.S. EPA 1989c
Body weight (adult) (kg)	70	U.S. EPA 1989c
Absorption fraction	10%	U.S. EPA 1988a

$$\text{Exposure} = \frac{C \times SA \times AF \times EF \times ED}{BW \times AT}$$

where,
SA = surface area (cm^2/event)
AF = soil - skin adherence factor

The absorption fraction is based on a study the was conducted by Versar/Mobil to measure the dermal bioavailability of dioxin (TCDD) and trichlorobiphenyl (TCB) sorbed to soil. Results of this study will be incorporated into a draft report titled Dermal Absorption of Dioxins and PCBs from Soil (U.S. EPA, 1988a) which is being revised by Versar for the Office of Toxic Substances. In vitro dermal absorption through human skin resulted in 8% absorption for TCB in low organic content soil (0.77% organic matter) and 10% in high organic content soil (19.35%). It is important to understand the uncertainties associated with these values. These are based on only one experiment and the TCB content in the soil was 1000 ppm.

To estimate the exposure through the dermal route, the average concentration of PCBs in the soil needs to be estimated and volatilization of PCBs accounted for using the same procedure described in the soil ingestion scenario. The average concentration of PCB in the soil after a period of 15 yrs is 0.38 ppm which is used for the child scenario and 0.28 after 30 yrs which is used for the adult scenario.

Dermal exposure is estimated for a child exposed to soil with an initial concentration of 1 ppm of PCBs.

$$\text{Exposure} = \frac{0.38\ \text{mg}}{\text{kg}} \times \frac{.40\ \text{m}^2}{\text{event}} \times \frac{132\ \text{events}}{\text{yr}} \times \frac{2.77\ \text{mg}}{\text{cm}^2} \times 15\ \text{yrs}$$

$$\times \frac{1}{38\ \text{kg}} \times \frac{1}{70\ \text{yrs}} \times \frac{\text{yr}}{365\ \text{days}} \times \frac{10^{-6}\ \text{kg}}{\text{mg}} \times \frac{10^{4}\ \text{cm}^2}{\text{m}^2}$$

$$= 8.6 \times 10^{-6}\ \text{mg/kg-day}$$

In this case, as in the adult calculation event = day. The exposure for an adult is estimated below.

$$\text{Exposure} = \frac{0.28\ \text{mg}}{\text{kg}} \times \frac{0.31\ \text{m}^2}{\text{event}} \times \frac{2.77\ \text{mg}}{\text{cm}^2} \times \frac{52\ \text{events}}{\text{yr}}$$

$$\times\ 12\ \text{yrs} \times \frac{1}{70\ \text{yrs}} \times \frac{1}{70\ \text{kg}} \times \frac{\text{yr}}{365\ \text{day}}\ \frac{10^{-6}\ \text{kg}}{\text{mg}} \times \frac{10^{4}\ \text{cm}^2}{\text{m}^2}$$

$$= 8.4 \times 10^{-7}\ \text{mg/kg-day}$$

Then risk is estimated by multiplying the total exposure (child + adult) times the cancer potency factor for PCB and multiplying by the absorption factor of 10%. The table below summarizes exposure and risk for the three soil concentrations.

Soil Concentration (ppm)	**Total Exposure (mg/kg-day)**	**Risk**
0.1	9.4×10^{-7}	7×10^{-7} [B2]
1.0	9.4×10^{-6}	7×10^{-6} [B2]
10	9.4×10^{-4}	7×10^{-5} [B2]

Vapor Inhalation Scenario

Exposure to volatilized PCB is estimated for an individual standing on site. If risk estimates exceed the cleanup value range of $10^{-4} - 10^{-7}$, then off-site air concentrations need to be estimated using dispersion models. In order to use dispersion models, site specific data such as meteorological data are necessary. On site air concentrations are estimated by using a "box model" described in the 1986 PCB guidance document (U.S. EPA, 1986a).

$$C = \frac{Q}{Ls \times V \times H}$$

where,
Q = flux rate (g/sec) Q = Emission rate x Area
Ls = width dimension of contaminated area (m)
V = average wind speed at mixing height (m/s)
H = mixing height (m)
At the mixing height the V = 0.5 x wind speed. A wind speed of 10 mph (4.5 m/s) which is the average in the United states is used. The flux rate is estimated using the model described in the 1986 PCB guidance document (U.S. EPA, 1986a). It is assumed that the contaminated soil is uncovered and the depth of contamination is 25 cm.

Emission rates are tabulated below.

Soil Concentration (ppm)	**Emission rates (g/cm^2-s)**
0.1	9.9×10^{-15}
1.0	9.9×10^{-14}
10	9.9×10^{-13}

To estimate the concentration in air, a mixing height of 2 m and a width Ls of 45 m are assumed. These are the values assumed in the 1986 PCb guidance document (U.S. EPA, 1986a). Air concentrations are tabulated below.

Soil Concentration (ppm)	**Air Concentration (g/m^3)**
0.1	9.9×10^{-10}
1.0	9.9×10^{-9}
10	9.9×10^{-8}

Inhalation exposure is estimated for an adult using the assumptions listed below.

Assumptions

Exposure Factor	**Value**	**Reference**
Adult Inhalation rate (m^3/day)	30	U.S. EPA, 1989f
Exposure Duration (yrs)	30	U.S. EPA, 1989f
Body weight		

adult (kg)	70	U.S. EPA, 1989f
Absorption fraction	50%	U.S. EPA 1986a

$$\text{Exposure} = \frac{9.9 \times 10^{-10}\ g}{m^3} \times \frac{30\ m^3}{day} \times 30\ yrs \times \frac{1}{70\ kg} \times \frac{1}{70\ yrs} \times \frac{10^3\ mg}{g}$$

$$= 1.8 \times 10^{-7}\ mg/kg\text{-}day$$

Exposure and risks are tabulated below for the three concentration values.

Soil Concentration (ppm)	**Exposure (mg/kg-day)**	**Risk**
0.1	1.7×10^{-7}	7×10^{-7} [B2]
1.0	1.7×10^{-6}	7×10^{-6} [B2]
10	1.7×10^{-5}	7×10^{-5} [B2]

Uncertainties

Sources of uncertainty include measured values that may not be accurate or representative, use of mathematical models which may not reflect the physical or chemical process actually occurring and assumptions on the selection of parameters in the models.

The analysis conducted used the physical and chemical properties of Aroclor 1254 to estimate air emission rates because this will yield the most conservative estimate. On the other hand, the Agency derived a Cancer Potency Factor for Aroclor 1260, which is the most toxic of the Aroclor, and uses it to be representative of other PCB mixtures. However, emission rate results may not be affected significantly since these two Aroclors have similar physical and chemical properties.

Human behavior patterns can strongly affect exposure results. Based on the limitations of our knowledge, the values for the exposure duration and frequency for the pathways considered are intended to be best reasonable upperbound estimates. For example, the vapor inhalation scenario assumes that a person will be breathing at a 30 m^3/day rate 24 hours/day for a period of 30 years. It also assumes that the concentration indoors will be the same as the concentration outdoors. These assumptions are considered reasonable since it is possible to observe certain subpopulations (i.e., housewife) spending the majority of their time at their residence without air conditioning.

In the soil ingestion scenario, the exposure values obtained do not account for children with pica behavior. Exposure estimates that will reflect this type of behavior will be considerably higher.

The rate of air emission through volatilization was calculated using the model developed in the 1986 PCB guidance (U.S. EPA, 1986a). The model is based on theoretical mass-balance equations to account for fundamental physical/chemical transport processes. No empirical data are available to validate the model. Values of the parameters that are input into the model are based on soil characteristics such as E and Ps, physical laws such as D_i, or determined empirically such as K_d. The latter is one of the major sources of uncertainty. The K_d depends not only on the chemical but also in the soil characteristics (i.e., organic carbon content). A K_d based on highly adsorbable soil was used which will result in a higher emission rate than if a less adsorbable soil such as sandy soils is used.

There are also uncertainties with the values used for absorption factors. For example, the absorbtion factor of 10% used in the dermal exposure scenario is based on very limited data. This assumption was based on one study which used a concentration of tetrachlorobiphenyl of 1000 ppm in the soil. It is likely that the absolute dermal absorption at lower concentrations in the soil will tend to be less.

APPENDIX C

DETERMINING APPROPRIATE LONG-TERM MANAGEMENT CONTROLS

DETAILED CALCULATIONS FOR CASE STUDY

Introduction

To illustrate the process of determining the appropriate long-term management controls for low-threat PCB contamination that will remain at a site, an example analysis is provided. Several source concentrations are evaluated.

The evaluation presented in this Appendix concentrates on ensuring that PCBs remaining will not adversely affect the quality of the ground water. Where concentrations remaining on site are higher than levels determined to be safe for direct contact, measures to prevent or limit access to the contaminated areas should be instituted. For concentrations within an order of magnitude of the health-based level, a soil or cement cover with a deed notice may be sufficient. Higher concentrations will require fencing and management of the cover over time.

The process used in this assessment involved two primary steps:

1. Evaluation of potential cap designs and their impact on infiltration through the contaminated zone.
2. Evaluation of the migration of PCBs to and into the ground water.

Once this was completed the concentrations of PCBs in the ground water was compared to the drinking water standard, .5 ppb, to identify the cap which prevented infiltration to the extent necessary to prevent degradation of the ground water.

This first section of this appendix provides a description of the site including the values of parameters necessary for the evaluation of PCB migration. Next the cap designs considered are presented with the description of the analysis of the infiltration expected. Finally, the model which estimates PCB migration to ground water is described and the resulting ground water concentrations for the various scenarios considered is presented.

Description of Site and Variations

The description of the site focusses on the factors that would affect the migration of PCBs and consequently indicate a need for a different level of control. These include:

- Size of PCB source area -- area and depth
- Concentration of PCBs
- PCB biodegradation rate

- Depth to ground water and thickness of saturated zone of interest
- Flow of ground water
- Rate of infiltration through the contaminated zone
- Soil porosity
- Organic carbon content of soil
- Bulk density of soil

The values of these factors used in the scenario evaluated in this example are discussed below.

Size of Site The site evaluated in this analysis covers 5 acres and the contamination is assumed to extend 10 feet vertically.

Concentration of PCBs PCB concentrations are assumed to be the same throughout the contaminated zone. Concentrations of 5, 20, 50 and 100 ppm were evaluated to provide examples where long term management controls short of the minimum technology requirements under RCRA and the chemical waste landfill requirements under TSCA can usually be justified. (As shown in Table 3-4, in the unusual case where PCBs at concentrations exceeding 500 ppm are left on site, minimum technology requirements are generally warranted.)

PCB Biodegradation Rate Since the model evaluates PCB migration over very long time frames (up to 10,000 years) it seemed appropriate to incorporate some estimate of PCB biodegradation. Several studies have documented highly variable PCB biodegradation rates (Quensen, 1988; Bedard, 1986; Brown, 1987). A half life of 50 years was assumed in this analysis.

Depth to Ground Water/Thickness of Saturated Zone The ground water table is encountered at 20 feet below the surface. A saturated thickness of 5 feet was assumed since this represents a conservative minimum screened interval for a well.

Flow of Ground Water The ground water is flowing at 310 feet per year. This is a typical flow for a sand and gravel aquifer and would be sufficient to provide 150 gallons per day with a 60-foot wide capture zone from a well screened over the first five feet. This is the minimum amount of water assumed to be used by a family of four. This reflects a very conservative scenario since few wells are screened through a thickness of only 5 feet. In most cases, wider intervals would be screend and greater dilution of PCBs would occur.

Rate of Infiltration Through the Saturated Zone The infiltration values used in this analysis were developed using the Hydrologic

Evaluation of Landfill Performance (HELP); version II, computer program (U.S. EPA, 1984). This program was used to estimate runoff, evapotranspiration, and infiltration rates through the four cap designs considered. Climatic conditions of the City of Seattle, Washington, were used to model rainfall, temperature, and other daily climatological data. Seattle was picked after preliminary estimates showed that the combination of climatic conditions in that city was one of the most extreme of all U.S. climates and would therefore represent a conservative scenario. A more detailed description of the use of the HELP model is presented below.

Soil Porosity The porosity of the soil was assumed to be 25% which corresponds to a mixed sand and gravel (Fetter, 1980).

Organic Carbon Content of Soil The first 10 feet of soil was assumed to have an organic content of 5%. The 10 feet below that was assumed to have an organic content of .5%. The organic content of the soil in the saturated zone was assumed to be .1%. This is a farely typical range.

Bulk Density of Soil A bulk density of 1.97 g/ml was used based on the porosity of .25 and the density of quartz, 2.63 g/ml.

Cap Designs/Infiltration Evaluation

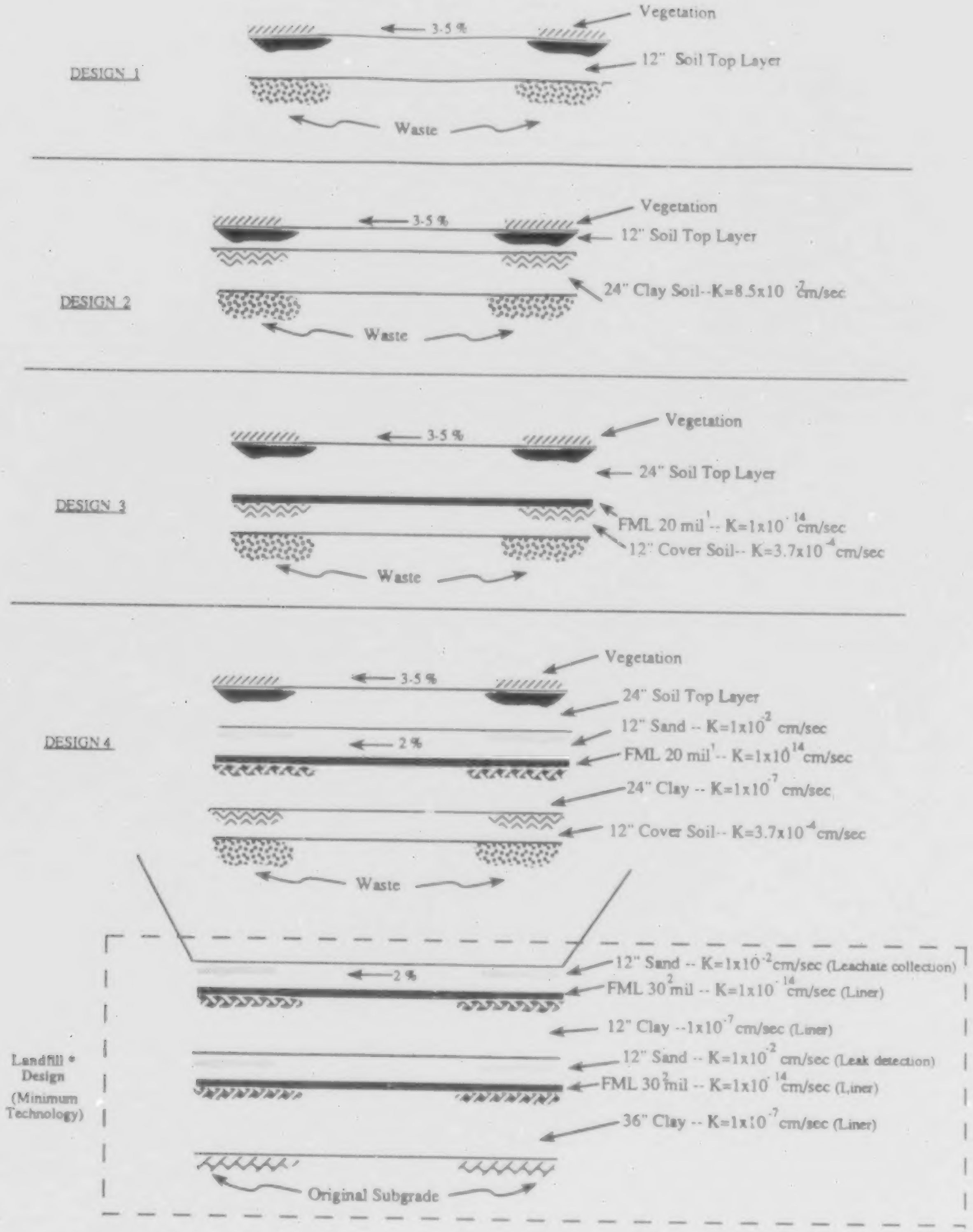
Four different cover systems were considered. These are shown in Figure C-1. As indicated cover system 1 is simply a 12 inch soil cap, cover system 4 reflects the RCRA cover design guidance (U.S. EPA, 1989d), and cover systems 2 and 3 reflect intermediate cover systems. Given the fact that climatological conditions are the same for all alternatives and that soil properties do not change, the only variables are the number of layers, their type, and their thicknesses. Brief descriptions of the physical properties of each layer used in the design models are presented below:

Vegetative soil layer This layer consists of sandy loam. The permeability of this soil is approximately 1 X 10^{-3} cm/sec. This permeability is considered moderate-to-high when compared to other soils.

Sand drainage layer This layer consists of clean, coarse sand. The permeability of this sand is approximately 1 X 10^{-2} cm/sec. This sand is considered a highly permeable soil.

Synthetic drainage layer (geonet) This layer is typically made of two high density polyethylene (HDPE) strands bonded together in a crossing pattern. Geonets are called geocomposites when they are sandwiched between two layers of geotextile fabric. Geonets and geocomposites are typically characterized by their transmissivities. The transmissivity of a layer equals the

Figure C-1
Cap Design Details


Vegetation
3-5 %
12" Soil Top Layer
DESIGN 1
Waste
Vegetation
3-5 %
12" Soil Top Layer
24" Clay Soil--K=8.5x10^{-7}cm/sec
DESIGN 2
Waste
Vegetation
3-5 %
24" Soil Top Layer
DESIGN 3
FML 20 mil[1] -- K=1x10^{-14}cm/sec
12" Cover Soil-- K=3.7x10^{-4}cm/sec
Waste
Vegetation
3-5 %
24" Soil Top Layer
12" Sand -- K=1x10^{-2} cm/sec
DESIGN 4
2 %
FML 20 mil[1]-- K=1x10^{-14}cm/sec
24" Clay -- K=1x10^{-7} cm/sec
12" Cover Soil-- K=3.7x10^{-4}cm/sec
Waste
12" Sand -- K=1x10^{-2}cm/sec (Leachate collection)
2 %
FML 30[2]mil -- K=1x10^{-14}cm/sec (Liner)
12" Clay --1x10^{-7}cm/sec (Liner)
12" Sand -- K=1x10^{-2} cm/sec (Leak detection)
FML 30[2]mil -- K=1x10^{-14}cm/sec (Liner)
36" Clay -- K=1x10^{-7}cm/sec (Liner)
Landfill * Design (Minimum Technology)
Original Subgrade

* RCRA Minimum Technology Landfill bottom liner design for remedial actions requiring RCRA landfill construction.

permeability of that layer multiplied by its thickness. Therefore, the permeability of a geonet can be calculated by dividing its transmissivity by its thickness. A transmissivity of 5 X 10^{-4} m^2/sec is assumed for a 1/4-inch-thick geonet, corresponding to a permeability of 7.8 cm/sec. This permeability is considered extremely high when compared to permeabilities of soil classes.

Compacted clay barrier layer This layer consists of mechanically compacted clay. The permeability of this layer is approximately 1 X 10^{-7} cm/sec. This clay is considered a highly impermeable soil.

Synthetic barrier layer This layer consists of a flexible synthetic membrane (FML). Typically, FMLs are considered impermeable. Thus, their effectiveness is measured by estimating the number and size of holes or defects that would be expected from manufacturing or installation operations. It is believed, for the purposes of comparison, that the permeability of this layer is approximately equivalent to 1 X 10^{-14} cm/sec. This permeability is considerably lower than the permeabilities of soil classes. However, in the HELP-II model this layer is considered impermeable and a leakage fraction, corresponding to the number and sizes of holes, is used to estimate the inflow rate through this layer.

Cover soil layer This layer consists of firm sandy clay loam. Its permeability is approximately 1 X 10^{-4} cm/sec. This permeability is considered moderate, when compared to permeabilities of other soils.

The Hydrologic Evaluation of Landfill Performance (HELP); version II, computer program (U.S. EPA, 1984) is a quasi-two-dimensional hydrologic model of water movement that was developed by the U.S. Army Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi, for the EPA Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio. Help-II models water movement across, into, through, and out of landfills. It uses climatological, soil, and landfill design data. The model accounts for the effects of runoff, surface storage, evapotranspiration, soil moisture storage, lateral drainage, hydraulic head on barrier layers, infiltration through covers, and percolation from liners. The model does not account for lateral inflow of ground water or surface water runon, nor does it account for surface slopes of the cover for runoff. The program reports peak daily, average monthly, and average annuual water budgets. The HELP-II model, which is currently being recommended by EPA for estimating infiltration through cover systems, has readily available climatological data for 102 U.S. cities, including Seattle, Washington. The climatological data consists of daily precipitation values from 1974 through 1978. Other daily climatological data are stochastically generated using a model developed by the Agricultural Research Service

(Richardson, 1984).

The soil and cover design data are entered either manually or by selecting default soil characteristics. Each landfill was assumed to have the following design characteristics:

1. SCS RCN, 69; this value corresponds to a runoff curve number, under average antecedent moisture conditions, for a fairly grassed soil that has a moderate infiltration rate.

2. Drainage media slope, 2 percent; this value represents the minimum cover slope allowed by RCRA minimum technology guidance; it has very little effect on the HELP model when under 20 percent.

3. Drainage length (spacing between collectors), 500 feet; this value was selected because RCRA does not require collection pipes in the cover system and therefore, it is unlikely to find any collectors on the cover.

Table C-1 summarizes the pertinent values for the four cap designs considered in this analysis. The infiltration value indicated is the value used for the infiltration entering the contaminated zone in the calculation of PCB migration to the water table.

PCB Migration To Ground Water

The PCB attenuation analysis was performed using EPA's one-dimensional unsaturated zone finite-element flow and transport: module, VADOFT (U.S. EPA, 1989g), coupled to the analytical solute/heat transport AT123D (Yeh, 1981). The finite-element module was used to evaluate vertical PCB transport in the unsaturated zone and to generate time varying mass flux rates at the water table which were used as input to AT123D which was used to simulate mass transport in the saturated zone (Figure C-2). AT123D was used to determine a time series of depth averaged concentrations beneath the PCB source. The results were then time averaged over the seventy-year period representing the years of peak concentrations occurring within a 10,000-year period.

VADOFT is a one-dimensional, non-linear, finite-element code used to evaluate variably saturated groundwater flow and solute transport. Solute transport in the unsaturated zone is described by the following governing equation:

$$o_v S_w R_v (dC/dt) = D_v (d^2C/dZ^2) - V_v (dC/dZ) - {}_v o_v S_w R_v C \qquad (1)$$

where: o_v = the effective porosity
S_w = the saturation
V_v = the vertical Darcy velocity
${}_v$ = the decay coefficient

Table C-1 COVER DESIGN SUMMARY TABLE (ANNUAL VALUES)					
Cover Design	**Site Area (Acres)**	**Precip. (Cu.Ft.)**	**Runoff (Cu. Ft.)**	**Evapotrans. (Cu. Ft.)**	**Infiltration (Cu. Ft.)/ Acre**
1	2	258,877	3,349	113,134	71,467
2	2	285,877	78,164	114,628	33,529
3	2	258,877	127,318	131,170	226
4	2	285,877	94,262	118,162	1

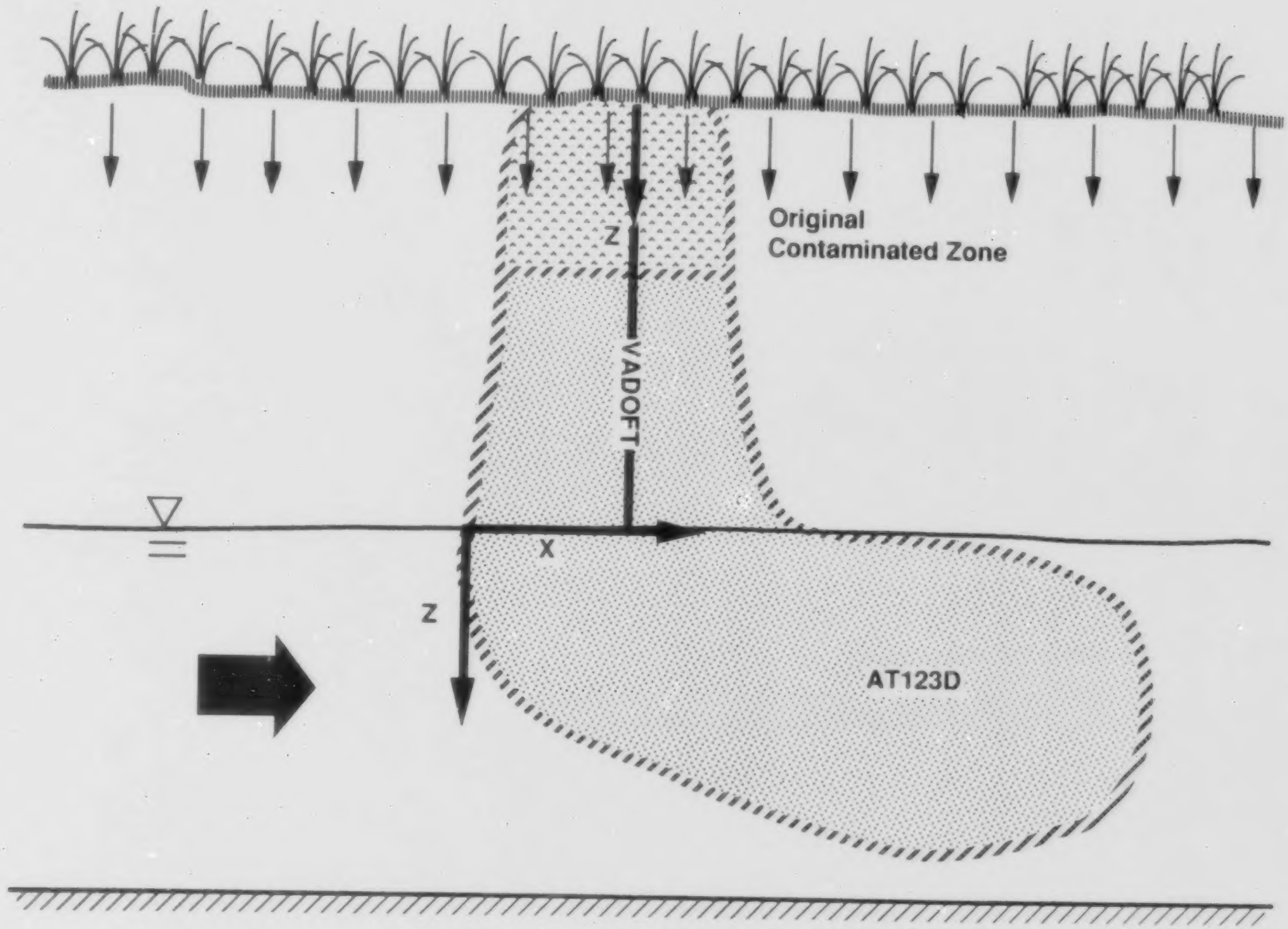


FIGURE C-2 EVALUATION AREAS FOR VADOFT AND AT123D

$R_v = 1 + ((K_dp_b)/(o_vS_w)$ = the retardation coefficient (2)
K_d = the adsorption coefficient
and
p_b = the bulk density of the soil

For transport simulations using a steady-state flow field and where there is no decay, or the decay rate is not a function of the saturation, the nonlinear flow analysis may be avoided for highly adsorptive chemicals. For chemicals with large adsorption coefficients (e.g., greater than 10) such as PCB's:

$$R_v \quad (K_dp_b)/(o_vS_w) \qquad (3)$$

and the saturation terms in Equations (1) and (2) cancel and can be disregarded. This circumvents the need for the nonlinear flow analysis and allows the transport analysis to be performed using a default Darcy velocity equal to the infiltration rate. Transient finite-element solute transport analyses were performed for the period of interest to generate time series of mass flux rates that were used as a boundary condition for AT123D.

AT123D, an analytical method based on Green's function techniques, simulates three-dimensional advective/dispersive transport in porous media. The three-dimensional solute transport equation on which AT123D is based can be written as:

$$D_x(d^2C/dx^2) + D_y(d^2C/dy^2) + D_z(d^2C/dz^2) - V_s(dC/dx) =$$

$$R_s(dC/dt) + R_s\ {}_sC + ((qC)/(Bo_s)) + M/o_s \qquad (4)$$

where: x, y, z = spatial coordinates in the longitudinal, lateral and vertical directions, respectively
C = dissolved concentration of chemical
D_x, D_y, D_z = dispersion coefficients in the x, y, and z directions, respectively
V_s = one-dimensional, uniform seepage velocity in the x direction
R_s = retardation factor in the saturated zone
t = elapsed time
s = effective first-order decay coefficient in the saturated zone
q = net recharge outside the facility percolating directly into and diluting the contaminant plume
B = the thickness of the saturated zone
M = the constant or time dependent mass flux rate

By taking the products of various directionally independent spatially integrated Greens functions the model allows for the application of linear, planar and volumetric mass flux sources to a porous medium which is of infinite extent in the flow direction and can be considered to be of either infinite or finite extent in the directions perpendicular to flow. Temporally, the Greens functions represent instantaneous sources which are numerically integrated with respect to time to allow for a constant mass flux or a time variant mass flux source condition. The general

solution can be written as follows:

$$C(s,y,z,t) = \quad (M/(o_s R_s))F_{ijk}(x,y,z,t;\ )d \qquad (5)$$

where: t = time of interest
= variable of integration

The term F_{ijk} is the product of the three-directionally-independent Greens functions (Yeh, 1981). Since the source term is a mass flux rate, a decay term accounting for dilution due to infiltration of water was utilized. This dilution factor is shown in the second to last term of Equation (4). For these simulations the source was approximated as a fully penetrating rectangular prismatic source with a surface area equal to the source area. The fully penetrating source was used to circumvent the need to depth average values of the concentrations.

RESULTS

The results of the analysis described above are summarized in table C-2. PCB concentrations in ground water were estimated for each of the four cap designs and four different PCB source concentrations. Based on this analysis, the following recommendations for caps could be made:

5 ppm PCBs Source At this concentration the threat of PCB migration to ground water at concentrations that would exceed the proposed MCL of .5 ppb under the given site conditions is unlikely. The maximum concentration averaged over 70 years (occuring after 945 years) is .099 ppb with only a soil cap. The soil cover would be recommended for sites in residential areas to prevent contact with concentrations above 1 ppm, the starting point action level.

20 ppm PCBs Source Again, the analysis indicates that the threat to ground water is not significant. With only a soil cap, the maximum concentration expected is .4 ppb. For sites in residential areas, a cement cover and a deed notice may be warranted to prevent contact with PCBs exceeding the 1 ppm starting point action level.

50 ppm PCBs Source At 50 ppm, PCB concentrations in the ground water are projected to exceed the .5 ppb level slightly -- approximately 1 ppb. At this concentration, for the site conditions presented, the second cap illustrated in Figure C-1 would be recommended. The combination of a low-permeability cover

Table C-2

SATURATED ZONE DEPTH AND TIME AVERAGED CONCENTRATIONS BENEATH THE SOURCE (PPB) AND TIME OF PEAK CONCENTRATION (YEARS)

Soil Concentration 5 ppm				**Soil Concentration 20 ppm**				**Soil Concentration 50 ppm**				**Soil Concentration 100 ppm**				T_{Peak} (Years)			
Cap Design 1	**Cap Design 2**	**Cap Design 3**	**Cap Design 4**	**Cap Design 1**	**Cap Design 2**	**Cap Design 3**	**Cap Design 4**	**Cap Design 1**	**Cap Design 2**	**Cap Design 3**	**Cap Design 4**	**Cap Design 1**	**Cap Design 2**	**Cap Design 3**	**Cap Design 4**	**Cap Design 1**	**Cap Design 2**	**Cap Design 3**	**Cap Design 4**
099	.029	0.0	0.0	.396	.116	0.0	0.0	.990	.290	0.0	0.0	1.98	.580	0.0	0.0	945	1645	—	—

SITE PARAMETERS

Source Area--5 Acres
Average Regional Flow 310 ft/year
Porosity of Soil--0.25
Bulk Density of Soil--1.97 g/ml
Time--Peak 70 years from 0-10,000 years
Contaminated zone organic content--5.0%
Clean unsaturated zone organic content--0.5%
Saturated zone organic content--0.1%
PCB half-life--50 years
Depth of Contamination--10 feet
Depth to Groundwater--20 feet
Thickness of Saturated Zone--5 feet

soil and the soil cap will prevent PCBs from migrating to the ground water at levels that exceed .5 ppb. With the reduce infiltration the maximum PCB concentration projected for the ground water (occurring after 1645 years) is .3 ppb. Again, a deed notice would be warranted to prevent direct contact with the soil in the future. Consistent with Table 4-2, a fence and some ground water monitoring (annual) would be recommended.

100 ppm PCBs Source At 100 ppm, PCB concentrations in the ground water are projected to exceed the .5 ppb level slightly -- approximately .6 ppb, even with the addition of a low-permeability cover soil. At this concentration, for the site conditions presented, the third cap illustrated in Figure C-1 would be recommended. The addition of a flexible membrane liner reduces infiltration sufficiently to prevent migration of PCBs to the ground water. Consistent with Table 4-2, a deed notice, fence, and periodic ground water monitoring would also be recommended.

APPENDIX D

CASE STUDIES

PEPPER STEEL, FL AND WIDE BEACH, NY

SITE NAME: Pepper's Steel and Alloys, Florida.

SITE DESCRIPTION: The site occupies 30-acres in Medley, Florida, approximately 10 miles northwest of Miami overlying the Biscayne Aquifer. This aquifer is used as a sole source drinking water supply for a large population. This location has been the site of a variety of businesses including the manufacture of batteries and fiberglass boats, repair of trucks and heavy equipment and an automobile scrap operation. Batteries, underground storage tanks, transformers, discarded oil tanks and other miscellaneous debris have accumulated as a result of disposal from past and present operations at the site. Contaminants have been identified within the soil, sediments and ground water.

WASTE DESCRIPTION: The contaminants of concern are polychlorinated biphenyls (PCBs), organic compounds and metals such as lead, arsenic, cadmium, chromium, copper, manganese, mercury, zinc and antimony. The quantities and concentrations of the primary contaminants are:

- PCBs - 48,000 cubic yards of soil at 1.4 ppm to 760 ppm,
  12,000 gallons of free oils with concentrations up to 2,700 ppm;
- Lead - 21,500 cubic yards of soil at 1,100 ppm to 98,000 ppm;
- Arsenic - 9,000 cubic yards of soil at concentrations greater than 5 ppm.

PATHWAYS OF CONCERN: Of significant concern is ground water transport of PCBs and lead to private wells and lead intake due to ingestion from direct contact with local soils. Air particulate matter containing PCBs provides a possible inhalation exposure pathway to onsite workers and offsite to neighboring residents.

TREATMENT TECHNOLOGY SELECTED: The recommended remedial alternative involves the excavation of PCB contaminated soils > 1 ppm and solidifying with a cement-based material followed by onsite placement. Soils contaminated with > 100 ppm lead or > 5 ppm arsenic will be excavated and chemically fixed (stabilized), thus reducing dissolution and diffusion rates. Free oils contaminated with PCBs will be treated offsite at a Toxics Substances Control Act (TSCA) approved incinerator. The offsite disposal of the free oil is cost-effective, implementable and satisfied the disposal requirements of TSCA Part 761.60(a). The solidified mass will be replaced onsite approximately 4-5 feet above ground water level.

EQUIVALENT TREATMENT: TSCA regulation 761.60(a)(4) requires that soils containing PCBs at concentrations greater than 50 ppm be destroyed by incineration or disposed in a chemical waste landfill. TSCA 761.60(e) provides for the approval of alternative methods of disposal which achieve a level of performance equivalent to incineration and protective of human health and the environment. The TSCA Spill Cleanup Policy (Part 761.120) covers spills which occurred since May 4, 1987. Spills which occurred before that date are to be decontaminated to requirements established at the discretion of EPA, usually through its regional offices. TSCA regulation 761.123 defines the relationship of the PCB Spill Cleanup Policy to other statutes. The Policy does not affect cleanup standards or requirements for the reporting of spills imposed, or to be imposed under other Federal statutory authorities including CERCLA. Where more than one requirement applies, the stricter standard must be met. PCB spills at Pepper's Steel took place during a period between 1960 through the early 1980's, therefore the PCB Spill Cleanup Policy is not applicable to this situation.

Incineration was deemed unacceptable due to high metal content in the contaminated soils. The volatilization of the metals would result in significant air discharges even with the implementation of air control mechanisms on the incinerator. Depending on the air control method used, scrubber waters or bag house filters contaminated with metals, and metals in the incinerated ash, would require appropriate disposal. Offsite disposal in a chemical waste landfill was eliminated as an option due to high cost, inhalation risks and concerns of offsite transportation of the material.

The selected remedial action addresses direct contact risk reduction by rendering the PCB matrix immobile through chemical fixation. In addition, the solidified mass will be covered with a 12-inch layer of crushed limestone to further eliminate these threats. Since PCB contaminated soil with concentrations > 1 ppm will be solidified, the action is consistent with the TSCA PCB Spill Cleanup Policy (761.125) which recommends a 10 ppm cleanup level for a site with nonrestricted access.

Of chief concern with the fixation method is the long term integrity of the fixed mass related to near surface ground water or infiltrating rainwater which may contribute to migration of the contaminants. To assess risk of injury to health or the environment, the EPA performed treatability studies on the solid mix to define performance standards. The tests performed to verify the integrity of the solidified matrix were Toxic Characteristic Leaching Procedure (TCLP), Extraction Procedure (EP) Toxicity, ANS 16-1 and a modified MCC-11. Fate and modeling (method not provided) were used to establish ground water action levels to monitor for failure of the technology. This remedial action warrants the submission of a waiver under 40 CFR 761.75(a)(4) for chemical waste landfills. Under this regulation the EPA Administrator may waive certain landfill requirements if it is determined that the landfill does not present an unreasonable risk of injury or adverse effects to health or the environment. This alternative satisfactorily addresses specific concerns in TSCA chemical waste landfill requirements by providing leachate collection, monitoring wells and a liner or fill to maintain the solidified mass above the ground water table.

Parameters for the treatability studies were set using the Water Quality Criteria Standard of 0.079 ng/l PCBs in water for PCBs at the property line several hundred feet from the solidified mass. Using ground water modeling, a level of 7 ppb PCB in leachate from the solidified mass was established as the maximum allowable concentration which would yield an acceptable risk at the receptor. Results from the treatability studies all indicated concentrations of PCBs in leachate of less than the detectable limit of 1 ppb.

This remedial action can be viewed to be consistent with two areas of TSCA PCB disposal policies. The solidification of the waste and leachate monitoring provide additional protective measures than are required in the chemical waste landfill regulations. The action also achieves a level of performance equivalent to incineration. Analysis of leachate from the solidified mass shows no PCBs at a detection limit of 1ppb, which supports the conclusion that the mobility of PCBs into the surrounding environment is essentially destroyed.

SITE NAME: Wide Beach, NY

SITE DESCRIPTION: The Wide Beach Development site is located in a small lakeside community in Brant, New York, approximately 48 km south of Buffalo. The Development covers 22 hectares, 16 of which are developed for residential use. The site is bordered on the west by Lake Erie, on the south by wetlands and on the east and north by residential and agricultural property. Between 1968 and 1987, 155 cubic meters (approximately 744 barrels) of waste oil, some containing polychlorinated biphenyls (PCBs), was applied to roadways for dust control by the Wide Beach Homeowners Association. In 1980, the installation of a sewer line resulted in excavation of highly contaminated soils and surplus soil was then used to fill in several yards and a nearby grove of trees.

The Erie County Department of Environmental Planning investigated a complaint in 1981 of odors coming from nearby woods. They discovered 19 drums in the woods and two contained PCB-contaminated waste oil. Alerted to a potential problem subsequent investigatory sampling revealed the presence of PCBs in dust, soil, vacuum cleaner dust, and water samples from private wells.

In 1985 the EPA performed an action to protect the public from the immediate concern until implementation of a long-term measure. The action involved the paving of roadways and drainage ditches, decontamination of homes by rug shampooing, vacuuming, and replacement of air conditioner and furnace filters and protection of individual private wells by installation of particulate filters.

WASTE DESCRIPTION: The primary containment at the Wide Beach site is PCBs, found over the majority of the site in all environmental media. The most significant contaminations were found in the sewer trench wells, soils adjacent to the roadways and wetlands sediments. Maximum PCB concentrations from the following areas were:

- drainage ditch samples - 1,026 ppm;
- yards and open lot samples - 600 ppm;
- unpaved driveway samples - 390 ppm;
- roadway samples - 226 ppm;
- sediment samples from marsh area - 126 ppm

The concentration of PCBs in one catch basin sample was 5,300 ppm. Investigations revealed that one of eight monitoring wells, and all six sewer trench wells were contaminated with PCBs. Drinking water sampling studies discovered PCB contamination in 21 of 60 residential wells, however, the level of contamination was low ranging from 0.06 ug/l to 4.56 ug/l.

PATHWAYS OF CONCERN: The primary pathway of concern is through the ingestion of PCB contaminated soils. Additional potential concerns involve the environmental impact of contamination on the surrounding marshlands.

TREATMENT TECHNOLOGY SELECTED: The recommended remedial alternative involves the excavation of contaminated soils > 10 ppm PCBs, onsite chemical treatment to destroy PCBs and soil residual replacement. The recommended treatment will involve removing 5,600 cubic meters of soil from the roadway, 8,500 cubic meters from drainage ditches, 1,500 cubic meters from unpaved driveways and 13,000 cubic meters from back and front yards. The chemical treatment for the 28,600 cubic yards of contaminated soil consists of a two step procedure. First, PCB molecules are extracted from the soils using solvents. The solvents are then treated with Potassium Polyethylene Glycol (KPEG), to remove chlorine atoms from the PCB molecule. This slurry is then pumped to a jacketed, internally agitated, batch reactor where the mixture is maintained at a soil moisture content of 2-3 percent for two hours at a temperature of 140 degrees Celsius while the dechlorination reaction takes place. This stage is followed by several water washes, and solids separation. The soils will be replaced onsite after the PCB contaminated matrix is treated to 2 ppm.

EQUIVALENT TREATMENT: TSCA regulation 761.60(a)(4) requires that soils containing PCBs at concentrations greater than 50 ppm be destroyed by incineration or disposed in a chemical waste landfill. TSCA 761.60(e) provides for the approval of alternative methods of disposal which achieve a level of performance equivalent to incineration and are protective of human health and the environment. Incineration was rejected as a remedial alternative option during the remedial investigation and was not documented in the Record of Decision. Offsite landfilling of the PCB soils was rejected due to concerns of excessive cost, dust release during excavation and possible exposure risks during transport.

Primary concerns with this treatment technology include the ability to attain the 10 ppm level for soil decontamination, and the potential formation of toxic end products through use of the reaction vessel. To address these concerns pilot plant treatability studies were performed to assess the effectiveness of potassium polyethylene glycol in dechlorinating the PCBs, and to determine important design parameters for the reaction vessel such as physical dimensions, operation temperatures and detention time. The results from one run revealed a reduction from 260 ppm in soil to under 2 ppm in the treated residual. Runs were performed on soil at 80 ppm PCBs which is the average concentration at the site. The results indicated that the 10 ppm PCB levels could be achieved consistently. Lab tests in the bench scale treatability study revealed no mutagenic effects with the soil, indicating that the residuals are non-toxic. The results of both KPEG bench scale and pilot plant treatability studies showed that PCB concentrations or 10 ppm or lower can be achieved successfully without hazardous end products, which eliminates the primary concerns with this treatment.

The 2 ppm cleanup level was derived by Best Demonstrated Available Technology (BDAT) values, TSCA policy, and health-based criteria identified in the risk assessment. The TSCA policy for evaluating whether treatment is equivalent to incineration (TSCA 761.60(e)) defines successful equivalent treatment by the level of PCBs in the treatment residual. A concentration of 2 ppm is considered to indicate the treatment has achieved a level of performance equivalent to incineration. The selected treatment destroys PCBs in contaminated soils therefore eliminating the potential risk identified in the risk assessment (i.e., direct contact threats). KPEG also provides protection through permanent and significant reduction of toxicity, mobility and volume of the waste, and complies with all relevant and appropriate requirements set forth in TSCA. Since this method has achieved a level of performance equivalent to incineration through pilot studies and it has been shown to be protective of human health and the environment, it is an acceptable alternative to incineration.

APPENDIX E

PCB DISPOSAL COMPANIES, COMMERCIALLY PERMITTED

NOV 29 1989

PCB DISPOSAL COMPANIES COMMERCIALLY PERMITTED

* Permitted to operate in all ten EPA Regions

COMPANY	ADDRESS	PHONE No.	
INCINERATOR			
ENSCO	P.O. Box 1957 El Dorado, AR 71730	501-223-4160	
ENSCO	P.O. Box 8513 Little Rock, AR 72215-8513	501-223-4100	*
General Electric	100 Woodlawn Ave. Pittsfield, MA 01201	413-494-3729	
Pyrochem/Aptus	P.O. Box 907 Coffeyville, KS	316-251-6380	
Rollins	P.O. Box 609 Deer Park, TX 77536	713-479-6001	
SCA Chemical Services	11700 South Stony Island Ave. Chicago, IL 60617	312-646-5700	
U.S. Department of Energy/ Martin Marietta Energy Systems	Federal Office Building Room G-108 P.O. Box E Oak Ridge, TN 37830	615-576-0973	
WESTON	One Weston Way West Chester, PA 19380	215-692-3030	*
ALTERNATE THERMAL			
Ecova Corporation	12790 Merit Drive Suite 220, Lock Box 145 Dallas, Texas 75251	214-404-7540	*
Ogden Environmental Services, Inc. (formerly GA Technologies, Inc.)	P.O. Box 85178 San Diego, CA 92138-5178	800-876-4336 or 619-455-3045	*
J.M. Huber Corporation	P.O. Box 2831 Borger, TX 79007	806-274-6331	
O.H. Materials Corporation	16406 U.S. Route 224 East P.O. Box 551 Findlay, Ohio 45839-0551	800-537-9540	*

CHEMICAL

American Mobile Oil Purification Co.	233 Broadway, 17th Floor New York, NY 10279	212-267-7073	*
Chemical Waste Management	1550 Balmer Road Model City, NY 14107	716-754-8231	
Exceltech, Inc.	41638 Christy Street Fremont, CA 94538	415-659-0404	
General Electric	One River Road Schenectady, NY 12345	518-385-3134	
General Electric	One River Road Schenectady, NY 12345	518-385-3134	*
National Oil Processing/Aptus	P.O. Box 1062 Coffeyville, KS 67337	800-345-6573	
Niagara Mohawk Power Corporation	300 Erie Boulevard West Syracuse, NY 13202	315-474-1511	
PPM, Inc.	1875 Forge Street Tucker, GA 30084	404-934-0902	*
ENSR Operations (formerly Sunohio)	1700 Gateway Blvd. S.E. Canton, OH 44707	216-452-0837	*
T & R Electric Supply Company, Inc.	Box 180 Colman, SD 57017	800-843-7994	
Transformer Consultants	P.O. Box 4724 Akron, OH 44310	800-321-9580	*
Trinity Chemical Co. Inc.	6405 Metcalf, Cloverleaf 3 Suite 313 Shawnee Mission, KS 66202	913-831-2290	

PHYSICAL SEPARATION

ENSCO	1015 Louisiana Street Little Rock, AR 72202	501-223-4100	*
National Electric/ Aptus	P.O. Box 935 Coffeyville, KS 67337	800-345-6573	
Quadrex HPS, Inc.	1940 N.W. 67th Place Gainesville, FL 32606	904-373-6066	*
Unison Transformer Services, Inc.	P.O. Box 1076 Henderson, KY 42420	800-544-0030	

PHYSICAL SEPARATION continued

General Electric	One River Road Schenectady, NY 12345	518-385-3134 *

PCB TRANSFORMER DECOMMISSIONING

G&L Recovery Systems, Inc.	1302 West 38th Street Ashtabula, Ohio 44004	216-992-8665

BIOLOGICAL

Detox Industries, Inc.	12919 Dairy Ashford Sugar Land, TX 77478	713-240-0892

PIPELINE REMOVAL

Texas Eastern Gas Pipeline Company	P.O. Box 2521 Houston, Texas 77252-2521	713-759-5167 *

CHEMICAL WASTE LANDFILLS

Casmalia Resources	559 San Ysidro Road P.O. Box 5275 Santa Barbara, CA 93150	805-937-8449
CECOS International	56th St. & Niagara Falls Boulevard Niagara Falls, NY 14302	716-282-2676
CECOS International	5092 Aber Road Williamsburg, OH 45176	513-720-6114
Chemical Waste Management	Alabama Inc. Box 55 Emelle, AL 35459	205-652-9721
Chemical Waste Management	Box 471 Kettleman City, CA 93239	209-386-9711
Chem-Security Systems Incorporated	Star Route Arlington, OR 98712	503-454-2777
Envirosafe Services Inc. of Idaho	P.O. Box 417 Boise, ID 83701	208-384-1500
SCA Chemical Services	Box 200 Model City, NY 14107	716-754-8231

CHEMICAL WASTE LANDFILLS continued

U.S. Ecology, Inc.	Box 578 Beatty, NV 89003	702-553-2203
U.S. Pollution Control, Inc.	Grayback Mountain Knolls, UT 84074	405-528-8371

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Region I
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APPENDIX F

LONG TERM MANAGEMENT CONTROLS AT PCB-CONTAMINATED SITES
SUPERFUND EXAMPLES

SUPERFUND EXAMPLES—LONG TERM MANAGEMENT CONTROLS

Superfund Site (ROD Date)	Initial Source & Problem	Disposition	Initial PCB Concentration Range (ppm)	Final PCB Concentration (ppm)	Geologic/Hydrogeologic Conditions	Cover Design	Bottom Liners	Leachate Collection/Removal and Leak Detection
1. Ottati and Goss, Kingston, NH (1/16/87)	• Buried drums, sludge	• Excavate • Off-site incineration • Cap • Aeration • Extract and treat groundwater	143 (soil)	20 (soil)	• Groundwater: 0-2 feet below surface • Geology: glacial tills, bedrock	9 inches top soil	• None	Groundwater wells planned for pump and treatment
2. Re-Solve, MA North Dartmouth, MA (7/24/87)	• Waste oil spread on dirt roads • Solvent reclamation facility	• Excavate • Cap • On-site treatment (dechlorination) • Wetland restoration • Extract and treat groundwater	15-52,000	25 (soil)	• Groundwater: 50-60 feet below surface • Geology: sand, gravel, till, bedrock	Regraded and grassed	• None	Groundwater wells planned for pump and treatment
3. Chemical Control Elizabeth, NJ (9/24/87)	• Variety of waste in drums	• In-situ fixation • Debris removal • Storm sewer repair • Secure site (fence)	0-6	0-6	• Groundwater: 1-3 feet below surface • Geology: sand/gravel silty sand, till, bedrock	1-3 foot gravel layer	• None • Natural impermeable clays	None
4. Wide Beach Brant, NY (9/30/85)	• Waste oil spread on dirt roads	• Excavation • Chemical treatment	0.05-1026	10	• Geology: silty sand/gravel, silty/clay; fractured shale	None (not feasible, a residential community)	• None	None
5. York Oil Moira, NY (2/8/88)		• Excavate • Stabilize • Off-site incineration • Extract and treat groundwater	1-210		• Groundwater: 30 feet below surface • Geology: glacial bedrock	None (stabilization process leaves treated soils impermeable)	• None • Natural impermeable clays	Groundwater wells planned for pump and treatment
6. Mowbray Engineering ______, AL (9/25/86)	• 3 acre swamp • Transformer repair plant	• Clear sewer • Excavate • Stabilize	N.D.-62 (soil)	25	• Groundwater: 18 feet below surface • Geology: sandy clay, rock, limestone	2 feet compacted clay, 2 feet vegetative layer, 2 feet sand, synthetic liner	• None	None
7. Pepper's Steel & Alloys Medley, FL (3/12/86)	• 30 acres trash	• Excavate • Stabilize • Off-site incineration • Cap • Extract and treat groundwater	1.5-760 (soil)	1	• Groundwater: 5-6 feet below surface • Geology: fill, peat, limestone	12 inches crushed limestone	• None	Down-gradient groundwater wells planned for pump and treatment
8. Belvidere Landfill Belvidere, IL (6/30/88)	• Landfill • Drum Disposal	• Excavate • Off-site incineration • Landfill • Cap • Extract and treat groundwater • Secure site	9-51,000	50	• Groundwater: 7 feet below surface • Geology: sand, gravel bedrock	RCRA cover	• None	Groundwater wells planned for pump and treatment
9. Fort Wayne Fort Wayne, ID (8/26/88)	• Dumping area • Recycling plant	• Excavate • On-site incineration • Cap • Contaminant wall • Extract and treat groundwater • Secure site	0.34-14.2	10	• Groundwater: 10-15 feet below surface • Geology: outwash sands and gravels, lake clays, silts, and fines	2 feet clay and 6 inches vegetative layer	• None	Groundwater wells planned for pump and treatment

SUPERFUND EXAMPLES–LONG-TERM MANAGEMENT CONTROLS

Superfund Site (ROD Date)	Initial Source & Problem	Disposition	Initial PCB Concentration Range (ppm)	Final PCB Concentration (ppm)	Geologic/Hydrogeologic Conditions	Cover Design	Bottom Liners	Leachate Collection/Removal and Leak Detection
10. French Limited Crosby, TX (3/24/88)	• 7.3 acre lagoon	• In-situ biological treatment • Stabilize	N.D.-616	23	• Groundwater: less than 50 feet below surface • Geology: topsoil; clay	None	• None • Natural impermeable clay	Groundwater wells may be planned for pump and treatment
11. Commencement Bay/Near Shore Tacoma, WA (12/30/87)	• Scrap yard	• Excavate • Stabilize • Cap • Re-grade	0-204	1	• Groundwater: 8-12 feet below surface • Geology: fill; sand; clay	2 inches sealed asphalt	• None	Groundwater monitoring system proposed
12. Pacific Hide and Fur Pocatello, ID (6/28/88)	• Transformers, capacitors • Scrap yard	• Excavate • Stabilize • Cap		10-25	• Groundwater: 20 feet below surface	Low permeability or RCRA cap	• Low permeability clay added to existing aquitard • Stabilized material to serve as liner	None
13.ᵃ Pinette's Salvage Yard Washburn, ME (5/30/89)	• Scrap yard • Transformer dielectric fluid spill	• Land Disposal identified as an alternative	7.4-300		• Groundwater: 0-20 feet below surface • Geology: sand and gravel; clay and silty clay; glacial fill; bedrock	4 inches asphalt; 12 inches stone; single synthetic layer; fill	• None	Slurry wall
14.ᵇ Sullivan's Ledge New Bedford, MA (Proposed 1/89)	• Quarry • Previous disposal	• Excavate • Stabilize • Cap • Extract and treat groundwater • Restore wetlands • Secure site • Restrict use • Long term monitoring	2,400 (soil)		• Groundwater: 100 feet below surface • Geology: quarries located in fractured bedrock	2 feet clay; 18 inches buffer soil; 12 inches sandy soil; 2 feet vegetative soil; vegetation	• None	Groundwater wells may be planned for pump and treatment
15.ᵃ New Bedford Harbor–Hot Spot Area Buzzard's Bay, MA (5/89)	• Industrial discharge	• Capping identified as an alternative	500-400 (sediment)		• Groundwater: contamination due to diffusion from sediment	3 feet sand/silt; synthetic layer	• None	None
16.ᵃᵇ Douglassville Disposal Site Berks County, PA Draft (9/88)	• Oil recycling	• Capping identified as an alternative	ND-30,000 (soils)		• Groundwater: less than 5 feet to 31 feet to surface • Geology: fill; natural over-burden bedrock	Synthetic liner; protective soil; topsoil; vegetation	• None	Groundwater barrier
17.ᵃᵇ Town of Norwood Norfolk County, MA Draft (1/89)	• Electrical equipment manufacturer • Previous disposal	• Capping identified as an alternative	10-26,000 (soils)	10-50	• Geology: fill; sand and gravel; glacial fill; bedrock	3 inches asphalt 2" aggregate; HDPE liner; 6" aggregate geotextile fabric; fill	• None	None

[a] Capping/land disposal identified as an alternative. [b] Proposed Plan.

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